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UNITED STATES GEOLOGICAL SURVEY
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MINERAL RESOURCES

OF THE

UNITED STATES

1916

H. D. McCASKEY
Geologist in Charge, Division of Mineral Resources

PART II—NONMETALS

E. F. BURCHARD and G. F. LOUGHLIN, Geologists in Charge

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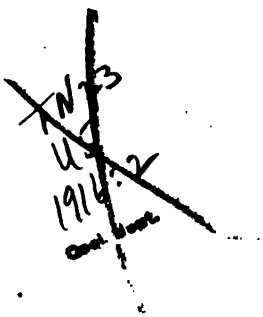

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MINERAL RESOURCES OF THE UNITED STATES, 1916—PART II.

FUEL BRIQUETTING.

By C. E. Lesher.

PRODUCTION.

The production of fuel briquets in 1916 was 295,155 net tons, valued at $1,445,662, an increase compared with 1915, of 73,618 tons, or 33 per cent, in quantity and $409,946, or 40 per cent, in value. The production in 1916 was the greatest recorded and exceeded that of 1914, the previous high record, by 44,520 tons. The progress of the

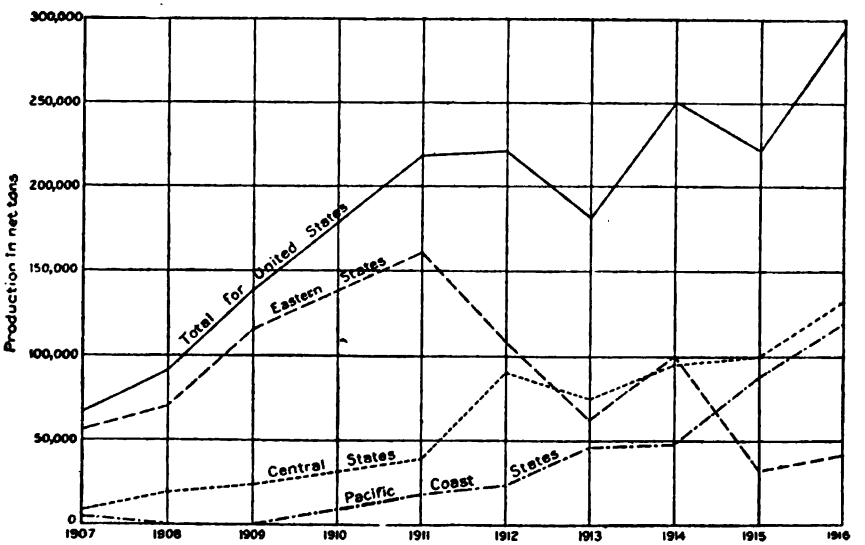

Figure 1.—Production of fuel briquets, 1907-1916, in the Eastern, Central, and Pacific Coast States, and in the United States.

industry for the 10 years from 1907 to 1916, inclusive, is shown graphically in the accompanying diagram.

The increase in the production of fuel briquets in 1916 is attributed both to the improvement in trade conditions arising from the unusual demand for coal and to a greater appreciation on the part of users of the value of briquets for household fuel. Improvements have been made in the process of manufacturing during the last two years,

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and the product from many of the plants gives off less of the heavy, tarry smoke that has been found objectionable by consumers. This improvement appears to have been largely accomplished by the use of asphaltic pitch in some form as a binder instead of coal-tar pitch.

It should be noted, however, that this apparent advantage of asphaltic pitch as a binder in fuel briquets may, in the long run, be offset by other advantages of coal-tar pitch as lower cost, ease of manipulation and, it is claimed, stronger and more waterproof briquets. Mr. W. H. Childs[1] states that the advances made in recent years in the art of briquetting have led to a reduction of the amount of binder required, and it is now possible to produce with coal-tar pitch binder a briquet that does not smoke badly, and in many localities where briquets will compete with bituminous coal the advantage in regard to smoke lies with the briquets. Furthermore, the development of the coal-tar industry requires that every possible output shall be found for coal-tar pitch, and to aid in the conservation of our timber resources it is necessary that increased markets for coal-tar pitch be developed, so that enough creosote oil can be produced to supply the demands of the wood-preserving industry.

Fuel briquets produced in the United States in 1915 and 1916.

	1915			1916		
	Number of operating plants.	Quantity (net tons).	Value.	Number of operating plants.	Quantity (net tons).	Value.
Eastern States:						
Maryland	1			1		
New Jersey [a]				1		
Pennsylvania	3			3		
Virginia	1			1		
	5	33,541	$95,174	6	38,833	$154,226
Central States:						
Colorado [a]				1		
Michigan	1			1		
Missouri	2			1		
North Dakota [b]	1					
Wisconsin	2			2		
	6	99,394	423,178	5	132,619	627,425
Pacific Coast States:						
California	2			2		
Oregon	1			1		
Washington	1			1		
	4	88,602	517,364	4	123,703	664,011
	15	221,537	1,035,716	15	295,155	1,445,662

[a] No production reported in 1915. [b] No production in 1916.

Briquets produced in the United States in 1907–1909 and 1911–1916, in net tons.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1907	66,524	$258,426	1913	181,859	$1,007,327
1908	90,358	323,057	1914	250,635	1,154,678
1909	139,661	452,697	1915	221,537	1,035,716
1911	218,443	808,721	1916	295,155	1,445,662
1912	220,064	952,261			

[1] President of the Barrett Co. Private communication.

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The number of plants in operation in 1916 was the same as in 1915. Three of the companies that operated in 1915 were, however, idle in 1916—the Scranton Anthracite Briquette Co., in Pennsylvania; the Northern Briquetting Co., at Minot, N. Dak.; and the Briquette Fuel Manufacturing Co., at St. Louis, Mo. The Gamble Fuel Briquette Co., at Harrisburg, Pa.; the Specialty Engineering Co., at Trenton, N. J.; and the American Coal Refining Co., at Denver, Colo., made their first production of fuel briquets in 1916. The net result was an increase of one in the number of active plants in the Eastern States and a decrease of one in the Central States. Nine of the companies reported increased output and three decreased output in 1916, compared with 1915. In each of the three divisions, Eastern, Central, and Pacific Coast States, the production was greater in 1916 than in 1915.

An interesting development in 1916 was the construction and operation of a plant by the American Coal Refining Co. at Denver, Colo., for briquetting the residue obtained by treating in retort ovens of the by-product type the noncoking subbituminous coal (black lignite) of northeastern Colorado. The operation of this plant in the later part of 1916 demonstrated the feasibility of the process, which converts low-grade subbituminous coal having a heat value of 9,000 to 10,000 British thermal units into a smokeless fuel that has the approximate composition of Pennsylvania anthracite and is said to have a heat value of about 14,000 British thermal units. Gas, tar, and ammonia are recovered as by-products in the operation of the process.

The Virginia Navigation Co. announced late in 1916 that work was soon to be begun on a large plant at Norfolk, Va., at which Pocahontas mine-run coal would be screened, the fines briquetted and, with the lump, loaded into vessels over the piers at Lambert Point. The principal object of this enterprise is to compete in the South American markets with fuel briquets of foreign manufacture.

The plant of the Lignite Fuel Co., in California, was dismantled late in 1916 and the machinery removed to Scranton, N. Dak., by the Johnson Fuel Co. This company has leased the lignite mine of the Scranton Coal Co. and, it was reported, will begin the manufacture of briquets as soon as the plant is erected.

The Scranton Anthracite Briquette Co., at Dickson City, Pa., remodeled its plant in 1916 and was ready to resume operations at the beginning of 1917.

RAW MATERIALS AND BINDERS.

Of the 15 briquetting plants in operation in 1916, 5 used anthracite as a raw material; 1, Arkansas semianthracite; 1, a mixture of anthracite and bituminous slack; 2, bituminous slack; 1, semibituminous slack; 1, a mixture of bituminous slack and subbituminous coal; 1, subbituminous coal; 1, brown lignite; and 2, oil-gas residue. One plant used coal-tar pitch as a binder; 7, asphaltic pitch; 3, mixed coal tar and asphaltic pitch; and 2, organic binders. No binder was used in briquetting the lignite or the petroleum residues at the two plants in California.

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Raw fuels used in making briquets in 1915 and 1916, in net tons.

	1915	1916
Anthracite culm and fine sizes	53,118	65,337
Semianthracite	123,944	136,358
Semibituminous		
Bituminous slack		
Lignite and subbituminous coal	37,742	88,731
Oil-gas residue		
	214,804	290,426

Briquetting plants operated in the United States in 1916.

Group.	Name of operator.	Address.	Location of plant.	Date put in operation.	Raw fuel used.
Eastern States.					
Maryland	Belgium Coal-Fuel Co.	509 Widener Building, Philadelphia, Pa.	Phoenix	1915	Bituminous slack.
New Jersey	Specialty Engineering Co.	520 Brunswick Avenue, Trenton, N. J.	Trenton	1916	Anthracite.
Pennsylvania	American Coalette Co.	3242 North Twenty-first Street, Philadelphia, Pa.	Philadelphia	1913	Do.
Do	Gamble Fuel Briquet Co.	704 Kunkel Building, Harrisburg, Pa.	Harrisburg	1916	Do.
Do	Lehigh Coal & Navigation Co.	437 Chestnut Street, Philadelphia, Pa.	Lansford	a1909	Do.
Virginia	Delparen Anthracite Briquet Co.	Parrott, Va.	Parrott	1915	Do.
Central States.					
Colorado	American Coal Refining Co.	730 First National Bank Building, Denver, Colo.	Denver	1916	Subbituminous coal.
Michigan	Coalette Fuel Co.	Seventeenth and Hancock Streets, Detroit, Mich.	Detroit	1909	Bituminous slack.
Missouri	Standard Briquette Fuel Co.	319 North Fourth Street, St. Louis, Mo.	Kansas City	1909	Arkansas semianthracite.
Wisconsin	Berwind Fuel Co.	122 South Michigan Avenue, Chicago, Ill.	Superior	1912	Semibituminous slack.
Do	Stott Briquet Co.	1203 Merchants Bank Building, St. Paul, Minn.	do	1909	Anthracite culm and bituminous slack.
Pacific Coast States.					
California	Lignite Fuel Co.	403 Call Building, San Francisco, Cal.	May	1915	Lignite.
Do	Los Angeles Gas & Electric Corporation.	645 South Hill Street, Los Angeles, Cal.	Los Angeles	1905	Carbon (petroleum residue).
Oregon	Portland Gas & Coke Co.	294 Yamhill Street, Portland, Oreg.	Linnton	1913	Do.
Washington	Pacific Coast Coal Co.	563 Railroad Avenue, South Seattle, Wash.	Briquetteville	1914	Bituminous slack and subbituminous coal.

a Plant destroyed by fire in 1909; reconstructed in 1911.

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SAND-LIME BRICK.[1]

By JEFFERSON MIDDLETON.

PRODUCTION.

The sand-lime brick industry made considerable progress in 1916. Both the quantity and the value of the material sold showed large increase compared with 1915, the value reaching its maximum and exceeding that of 1913, the previous year of maximum value, by $235,748, or 19 per cent. This industry, in common with others, suffered considerably from scarcity of labor; otherwise the output in 1916 would probably have been even larger. The prospects for 1917 appear to indicate that the output and value for 1916 will be exceeded.

The increase in the quantity of sand-lime brick sold in 1916 over 1915 was 47,701,000 brick, or 27 per cent, and the increase in value was $338,969, or 30 per cent. The number of operators reporting marketed product continued to decrease, and for 1916 was the smallest since 1903, the first year for which statistics were collected by the United States Geological Survey; but the average value of sales per active operator was $27,813 compared with $20,270 in 1915.

Twenty-one States reported sales of sand-lime brick in 1916, a decrease of one. Iowa and Nebraska, which reported brick in 1915, reported none in 1916, and Illinois entered the list of producers. Fifteen of the 20 States that reported marketed production in both 1915 and 1916 showed increase in value in 1916. Michigan showed the largest increase—$212,763, or nearly 75 per cent.

The following tables show the annual value of the sand-lime brick sold since 1903, and both the quantity and value of sales in 1915 and 1916 by States. In 1916 there were less than three operators reporting sales in each of 11 States, and therefore, in order to avoid the disclosure of confidential returns made to the Geological Survey, the figures for these States have been combined under "Other States."

In 1916, as for many years, Michigan was the leading State in sales of sand-lime brick, reporting nearly one-third of the quantity and more than one-third of the value of all sales; Minnesota was second, as in 1915; and Pennsylvania was third in quantity and Massachusetts was third in value of sales. Common brick represented 98 per cent of the total value in 1916.

The average price per thousand for common brick in 1916 was $6.43, compared with $6.22 in 1915. For front brick the average price was $9.64, compared with $10.21 in 1915.

[1] The tables of production in this report were prepared by Miss K. W. Cottrell.

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Sand-lime brick sold in the United States, 1903–1916.

Year.	Number of operators reporting sales.	Value of product.	Year.	Number of operators reporting sales.	Value of product.
1903	16	$155,040	1910	76	$1,169,153
1904	57	463,128	1911	66	897,664
1905	84	972,064	1912	71	1,200,222
1906	87	1,170,005	1913	68	1,238,325
1907	94	1,225,769	1914	62	1,058,512
1908	87	1,029,699	1915	56	1,135,104
1909	74	1,150,580	1916	53	1,474,073

Sand-lime brick sold in the United States in 1915 and 1916.

State.	1915 [a]			1916 [b]		
	Number of operators reporting sales.	Common brick.		Number of operators reporting sales.	Common brick.	
		Quantity (thousands).	Value.		Quantity (thousands).	Value.
California	3	1,533	$12,158	3	347	$3,337
Florida	4	[c] 13,078	[c] 77,575	4	15,350	90,794
Indiana	3	6,491	31,702	3	10,966	54,148
Massachusetts	4	13,362	101,250	3	16,255	110,333
Michigan	11	47,285	286,948	12	72,004	499,711
Minnesota	4	26,489	151,128	4	28,975	178,828
New York	3	[c] 16,504	[c] 121,114	3	15,821	109,037
Pennsylvania	3	10,573	56,848	3	16,838	94,328
South Dakota	3	2,554	18,402	3	3,996	32,139
Texas	3	6,581	52,941	3	6,214	45,092
Wisconsin	4	17,161	94,064	[d]	[d]	[d]
Other states [e]	11	18,032	130,974	12	[e] 40,578	[e] 256,326
	56	179,643	1,135,104	53	227,344	1,474,073

[a] Common brick, except 4,120,000 front brick, valued at $42,080, made in California, Florida (813,000, valued at $7,440), Indiana, Kentucky, Massachusetts, Michigan, Minnesota, Nebraska, New York, Texas, and Wisconsin.

[b] Common brick, except 3,501,000 front brick, valued at $33,733, made in California, Connecticut, Florida (97 3,000, valued at $8,276), Indiana, Michigan (888,000, valued at $7,845), New Jersey, North Dakota, Texas, and Wisconsin; and 175,000 fancy brick, valued at $2,700, made in California, New York, and Ohio.

[c] Includes fancy brick.

[d] Included in "Other States."

[e] Includes, 1915: Connecticut, District of Columbia, Georgia, Idaho, Iowa, Kentucky, Nebraska, New Jersey, North Dakota, Ohio, and Washington; 1916: Connecticut, District of Columbia, Georgia, Idaho, Illinois, Kentucky, New Jersey, North Dakota, Ohio, Washington, and Wisconsin.

PUBLICATIONS.

The Bureau of Standards, Department of Commerce, has recently published a comprehensive report on sand-lime brick.[1] This report reviews the history of the industry, goes at some length into the chemistry of sand-lime brick, and describes the raw materials used, the processes of manufacture, and tests of the finished product. An appendix contains descriptions of some of the operating plants in various sections of the country.

[1] Emley, W. E., Manufacture and properties of sand-lime brick: Bur. Standards Tech. Paper 85, 1917.

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LITHIUM MINERALS.

By WALDEMAR T. SCHALLER.

INTRODUCTION.

The production of lithium minerals constitutes a very small part of the world's total output of minerals. Lithium minerals have been produced steadily in the United States every year since 1898, and annual reports on their production were made by the United States Geological Survey from 1900 to 1905. Since 1905 only a single report, now exhausted, has been published.[1] New uses for lithium compounds have been developed from time to time, but as old uses have been discarded the demand has not increased much, and present conditions do not seem to warrant expectations of increased demand beyond the ability of existing companies to fill.

Lithium minerals from Saxony and Bohemia were used as sources of lithium salts before 1886, when France began to produce amblygonite. About 1898 spodumene was regularly mined in South Dakota, and a few years later lepidolite was mined in California. Later, amblygonite was developed in both States, and these three minerals from South Dakota and California have furnished almost the entire production of lithium in the United States. Formerly these minerals were mostly exported crude; for several years before and also since the beginning of the European war the crude minerals have been treated in this country.

The following definitions of the compounds of lithium are given to enable the reader to understand clearly the meaning of the terms used.

Lithium is an elementary substance which is present in all these minerals. It is a silver-white, very soft metal, which forms the oxide or some other salt on exposure to the air and which decomposes water, forming the hydroxide of lithium; for these reasons metallic lithium does not occur in nature. Compounds are called lithium carbonate, lithium phosphate, lithium silicate, etc.

Lithia, the oxide of lithium, is a white solid soluble in water and also readily undergoing change on exposure to the air. Unfortunately the term lithia is also popularly applied to both the hydroxide and the carbonate, and hence some confusion exists as to usage. The term lithia should be used only for lithium oxide. The hydroxide and the carbonate are both soluble in water, but the carbonate could exist in nature under conditions similar to those under which the carbonate of sodium is found. The scarcity of lithium minerals, however, prevents the natural accumulation of any deposit of lithium carbonate.

[1] Hess, F. L., Lithium: U. S. Geol. Survey Mineral Resources, 1909, pt. 2, pp. 649–653, 1911.

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Lithium mica is used to designate any mica containing an appreciable quantity of lithium. Lepidolite, which contains about 4 per cent of lithia, is the most common of these lithium micas, but others are known, such as zinnwaldite, cryophyllite, polylithionite, protolithionite, and irvingite. Cookeite, a micaceous mineral containing lithium, has also been erroneously called lithia. The term "lithium mica" (not "lithia mica"), if not further defined, is generally understood to refer to lepidolite.

The term "mica lithia" has no meaning, and the term "lithia rock," which has been used to designate the Pala lepidolite, should give way to lithium mica or lepidolite. "Lithionite" is a term which likewise has been occasionally applied to lithium micas, especially to lepidolite.

SOURCES.

SPODUMENE.

Spodumene is a silicate of aluminum and lithium, generally containing small quantities of other elements such as sodium or manganese. The spodumene crystals are distinct and are prismatic in shape and habit, with a nearly square, rounded, or flat cross section. Parallel striations or lines in the direction of elongation are a prominent feature of the crystal faces. The cleavage is in two directions, at an angle of 93°, and a few crystals show also a parting or plane of separation half way between the prism faces and parallel to the long flat face of the flat or tabular crystals. Most spodumene is opaque and dull gray-white, usually with a tinge of green. Rarely clear and transparent varieties having a glassy luster are found; these, if strongly colored, are valuable for gems. The clear, transparent varieties are colorless, pink, lilac, green, yellow, and blue, and to some of them gem names have been applied; the green variety is called hiddenite, the yellow is triphane or Brazilian chrysoberyl, and the lilac is kunzite. The hardness of the fresh spodumene is 6.5 to 7; quartz will therefore just scratch the mineral. Partly altered spodumene is softer. The density of the mineral is about 3.17; it is therefore much heavier than feldspar. Before the blowpipe flame spodumene fuses easily to a white or gray enamel and at the same time gives the flame the characteristic deep crimson color of lithium.

Spodumene is seldom found in crystals less than an inch long, and it characteristically grows into large crystals, whose length is measured in inches or feet. The largest known spodumene crystals are found in South Dakota, and a description of these gigantic crystals, with illustrations, has recently been published.[1] Blake,[2] as early as 1885, wrote—

> One crystal which extends horizontally parallel with a drift is 36 feet in length in a straight line and is from 1 to 3 feet in thickness * * *. Crystals from 5 to 20 feet long are numerous and incline in all directions.

Hess [3] mentions a crystal that measured "42 feet in length, with a cross section of approximately 3 by 6 feet. Part was decayed and useless, but about 37 tons of spodumene was mined from it."

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[1] Schaller, W. T., Gigantic crystals of spodumene: U. S. Geol. Survey Bull. 610, p. 138, 1916.
[2] Blake, W. P., Spodumene crystals of gigantic size: Am. Jour. Sci., 3d ser., vol. 29, p. 71, 1885.
[3] Hess, F. L., Lithium: U. S. Geol. Survey Mineral Resources, 1909, pt. 2, p. 651, 1911.

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Ziegler [1] describes, in part, the immense size of the spodumene crystals as follows:

> The crystals are often of enormous size. In the Etta mine, where they are best exposed both in the open cut and in the tunnel, they frequently attain a diameter of 3 to 4 feet and a length of 30. The largest "log" so far found was 42 feet long and of 5 feet 4 inches maximum diameter. This one log alone would yield 90 tons of spodumene.

Two photographs of such gigantic crystals are reproduced in Plate V of Survey Bulletin 610.[2] One photograph, taken by S. S. Smith at the Etta mine, near Keystone, S. Dak., in 1904, shows the largest recorded "log" that had been uncovered up to that time. The length of the exposed portion is about 47 feet. Two molds of crystals are shown in the second photograph. The length of each of these molds, measured by the writer in 1904, was 40 feet and the thickness varied from 2½ to 3 feet. In another part of the mine was a spodumene log 25 feet long and from 3 to 3½ feet in diameter.

These spodumene logs rarely contain other minerals as impurities. On a few logs quartz was seen in small quantity, and more rarely cassiterite or strüverite occurs embedded in the spodumene or forms small veins therein, and all follow cleavage planes. The spodumene cleaves readily and as mined is broken into blocks about a foot in diameter. A layer of some alteration product, several inches thick, coats many of the crystals. It has been estimated that 25 tons of waste rock have to be removed to extract 1 ton of spodumene.

LEPIDOLITE.

The term lithium mica is generally regarded as referring to lepidolite, the commonest of the micas containing lithium. The mineral is of complex chemical composition, being a silicate, with fluorine and water, of aluminum, potassium, and lithium, and containing small quantities of iron, manganese, sodium, and other elements. As the result of a detailed study of the mineral, pure lepidolite is regarded [3] as a silicate, with fluorine, of aluminum, potassium, and lithium, whose chemical composition is expressed by the formula $12SiO_2.3Al_2O_3.3Li_2O.2K_2O.8F$. Most occurrences of lepidolite are isomorphous mixtures of the pure mineral with muscovite, which is generally free from lithium.

Lepidolite is mostly found as a compact aggregate of very small scales forming scaly granular masses that are many feet thick, although the individual scales or micaceous plates are small, rarely being an inch across the cleavage. The mineral also forms short, rounded hexagonal prisms and very rarely distinct tabular crystals having well-developed bright terminal faces. A most exceptional occurrence of lepidolite is at Wakefield, Canada, where plates or sheets a foot across have been found. Lepidolite also commonly forms a rim or border on larger crystals of muscovite, the purple rim of lepidolite showing very strikingly against the greenish muscovite.

The prominent cleavage by which lepidolite will split into thin elastic sheets is well developed. These thin sheets have a pearly

[1] Ziegler, Victor, The mineral resources of the Harney Peak pegmatites, II: Min. and Sci. Press, vol. 108, p. 654, Apr. 18, 1914.
[2] Schaller, W. T., op. cit., p. 138.
[3] Schaller, W. T., The gem tourmaline field of southern California: U. S. Geol. Survey Prof. Paper 92 (in preparation).

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luster and are transparent and soft, the hardness being about 3. The density of the mineral is about 2.85. Most lepidolite has a decided pink or purple tint, the mineral being either gray, white, yellow, pink, red, purple, or blue. Before the blowpipe flame lepidolite fuses easily to a white glass—it is much more fusible than spodumene—at the same time coloring the flame a deep crimson.

AMBLYGONITE.

Amblygonite is a phosphate, with fluorine and water, of aluminum and lithium. If the fluorine predominates over the combined water the mineral is amblygonite; if the combined water is present in larger proportion the mineral is montebrasite. Fremontite is a related phosphate, with water, of aluminum and sodium with only a little lithium.

Crystals of amblygonite are very rare, the mineral as found being compact and massive, with cleavage surfaces extending several inches across. It resembles white feldspar and also spodumene to a less extent. It has a hardness of 6 and a density of about 3.1. Its usual color is white, but it has been found with green, blue, yellow, gray, or brown tints. Before the blowpipe flame amblygonite fuses easily to an opaque white enamel, coloring the flame crimson.

TRIPHYLITE.

Triphylite is a phosphate of iron and lithium, and lithiophilite a corresponding phosphate of manganese and lithium. Neither mineral is known to exist in nature in the pure state. In all occurrences the mineral contains both iron and manganese, and in most occurrences the iron predominates over the manganese; hence the name triphylite. Crystals are rare and are usually large and uneven. The mineral is commonly in cleavable masses of a greenish-gray, bluish-gray, brown, or black color. The hardness is 5; it is much less in the altered varieties. The density is 3.5. This mineral fuses easily before the blowpipe flame to a brownish-black bead, coloring the flame crimson. Triphylite as found is usually more or less altered and seamed or coated with black manganese oxides or with purple purpurite.

OTHER LITHIUM MINERALS.

Petalite.—Petalite, a rare mineral, is a silicate of aluminum and lithium; it has the formula $LiAl(Si_2O_5)_2$ and theoretically should contain 4.9 per cent of lithia (Li_2O). Analyses show the following percentages of lithia (Li_2O): 2.62, 2.77, 3.63, 4.22. The mineral is found, rarely, as minute colorless crystals and, more commonly, as glassy white, foliated, and cleavable masses that are white, gray, or pink in color. The hardness is that of feldspar, but the density (2.4) is much less. The mineral phosphoresces with a blue light on being gently heated; in a blowpipe flame it whitens and fuses on thin edges, coloring the flame crimson. The mineral is not soluble in acids. The only known deposit of commercial size is in Sweden.

Zinnwaldite.—The properties of zinnwaldite are similar to those of lepidolite; it is a micaceous mineral of violet, yellow, brown, or gray color. In composition it is similar to lepidolite but contains in addition about 10 per cent of iron oxide. It may be easily dis-

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tinguished from lepidolite, for when heated before a blowpipe flame it fuses to a black magnetic glass, whereas lepidolite gives a white or gray nonmagnetic glass. The crimson color imparted by zinnwaldite to the flame readily distinguishes it from the other lithium-free micas containing iron. The iron-lithium micas, rabenglimmer, cryophyllite, polylithionite, and protolithionite are closely related to zinnwaldite. The deposits in the Erzgebirge, in Bohemia and Saxony, have been exploited for their lithium content. Analyses of these micas have shown the following percentages of lithia (Li_2O): 3.28, 3.36, 3.39, 3.73, 4.06, 4.81, 4.87, 4.99. Polylithionite from Greenland contains 9.07 per cent of lithia.

TYPICAL COMPOSITION OF LITHIUM MINERALS.

The typical chemical composition of the lithium minerals used in the manufacture of lithium salts is shown below. The presence of impurities (associated minerals and alteration products) tends to lower the available percentage of lithium in the ore treated.

Spodumene readily undergoes alteration into a mixture of feldspar and muscovite, or into mica (including cookeite) alone, and also into clay. These alteration products if confined to the surface may be scraped off, as they are in the mines in South Dakota. Associated minerals so intimately mixed with the spodumene as not to be separable therefrom are seldom present.

Lepidolite is not known to alter directly to any other mineral, but the deposits of it usually contain some intermingled pink and green tourmalines, albite, and quartz.

Amblygonite is known to alter locally into other minerals; but the deposits of amblygonite that have been mined show almost no alteration and are, moreover, unusually free from associated minerals. Amblygonite is unquestionably the best mineral source for the extraction and manufacture of lithium compounds.

Triphylite has been mined to a small extent in South Dakota. Its ready oxidation and hydration with loss of lithium suggest that the lithium content of the mineral after mining is probably much less than the original percentage.

Typical composition of lithium minerals mined as sources of lithium compounds.

	Spodumene.	Lepidolite.	Amblygonite.	Triphylite.
Silica (SiO_2)	64	51	0	0
Alumina (Al_2O_3)	27	27	34	0
Lithia (Li_2O)	7	4	9	9
Potash (K_2O)	0	11	0	0
Phosphoric acid (P_2O_5)	0	0	48	45
Water (H_2O), combined	0	2	5	0
Fluorine (F)	0	7	5	0
Iron, manganese, lime, magnesia, soda	2	1	1	46
	100	103 a−3	102 a−2	100
		100	100	

a The oxygen equivalent of the fluorine must be deducted from the first summation.

The percentages of lithia (Li_2O) in analyzed spodumene are as follows: 7.04, 7.09, 7.45, 6.89, 6.99, 7.62, 7.05, 6.82, 7.20, 6.88, 7.02.

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These percentages represent small quantities of carefully selected and purified material and are therefore higher than for the bulk content of a large shipment of the mineral. Three different samples of spodumene from South Dakota have been reported as yielding 1.18, 3.56, and 6.16 per cent of lithia. The theoretical percentage of lithia in spodumene is 8.0 per cent.

The percentages of lithia (Li_2O) in analyzed lepidolite are as follows: For a series of lepidolites from Maine: 4.90, 4.20, 4.49, 4.34, 4.98, 3.87, 4.03; for a series from California: 2.39, 4.27, 4.31, 4.63, 5.12, 6.06; for five from Western Australia: 1.13, 2.05, 2.60, 3.07, 5.83. The theoretical percentage of lithia in pure lepidolite, as suggested by the writer, is 6.43, a value seldom reached by the mineral as found, for the natural occurrences are all isomorphous mixtures of pure lepidolite and muscovite, which is free from lithia.

Amblygonites, including the corresponding hydrophosphate montebrasite, have given on analysis the following percentages of lithia: 8.97, 7.92, 9.46, 9.54, 9.82, 9.24, 9.80, 9.52, 9.88, 9.31. For a series of amblygonites from the Black Hills, S. Dak., the following are the percentages of lithia: 9.87, 7.57, 6.02, 5.93. 4.87, 4.5, and 3.87. The theoretical percentage of lithia in pure amblygonite $Li(AlF)PO_4$ and pure montebrasite $Li(AlOH)PO_4$ is 10.1 per cent.

Analyses of triphylite and of lithiophilite, the corresponding manganese phosphate, have given the following percentages of lithia: 8.15, 9.36, 8.79, 9.26, 8.63. The theoretical percentages are 9.5 and 9.6. Analyses of altered triphylites and lithiophilites, which would more nearly correspond to the value of the lithia content of the mineral as mined, show 1.79, 5.66, 4.83, and 3.73 per cent.

OCCURRENCE.

SOUTH DAKOTA.

The Black Hills of South Dakota consist of a series of uplifted sedimentary formations dipping away radially from a central core of pre-Cambrian metamorphic and igneous rocks. The schists and the invading granites are cut by great numbers of pegmatite dikes, which show all gradations from a typical "giant granite" to well-defined quartz veins. The lithium minerals are found in these coarse pegmatite dikes.

The Etta mine, near Keystone, is the best known and was originally opened for mica, was then further developed for tin, and is now worked for spodumene. It is on a small hill rising about 250 feet above the valley. The country rock is a biotite-quartz-mica schist, invaded by numerous pegmatite dikes remarkable for their coarseness. The dikes in this vicinity have round or elliptical outcrops.

Several other neighboring mines have produced small quantities of spodumene, and a brief description of the most noteworthy follows: The Everly dike is a large cylindrical pegmatite mass, rising about 150 feet above the surrounding schists and having a diameter of about 200 feet. An outer layer of muscovite, in places several feet across, surrounds the pegmatite mass. The pegmatite consists mostly of quartz in which spodumene crystals, smaller than those from the Etta mine, are embedded. The spodumene is much fresher than at the Etta mine; it commonly has a greenish color and

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is translucent in small areas. In consequence of its firmer character and more quartzose matrix, it is much harder to mine. The Greyhound and the Harris claims are on outcropping pegmatite similar to that of the Etta mine. Open cuts, of small size, have been made in both claims and have exposed numerous logs of spodumene. The mineral is friable and soft and resembles that of the Etta mine. The Spodumene lode is another large pegmatite mass developed by tunnels and open cuts. Some open-cut work has exposed a log of spodumene 40 inches in diameter. The quality of the spodumene is similar to that at the Etta mine. A little lepidolite occurs here, and massive apatite is somewhat abundant.

Spodumene is, in fact, abundant in nearly all the pegmatites of this region and has been reported from the following claims in addition to those already mentioned: Hugo, Boomerang, Sunday Fraction, Bull Con, and Swanzy, near Keystone; Dyke Lode, near Bismuth; Wood Tin, between Harney City and Hayward; Beecher or Bond, near Custer. It is found in many pegmatites near Keystone, Custer, Hill City, Glendale, and Hayward.

Amblygonite occurs in large nodular masses in the Peerless mine, half a mile northeast of the Etta. This mineral has been mined also at the Hugo (formerly the Christiensen), where a body of amblygonite 15 by 22 by 40 feet was encountered. Nodules of amblygonite weighing half a ton are common, and many smaller nodules are disseminated throughout the pegmatite. Masses weighing 400 pounds are numerous. Other claims showing abundant amblygonite are the Equality lode and the Bob Ingersoll, near Keystone; Beecher or Bond, near Custer; Tin Queen, near Oreville; and Nichols, near Hayward. A total production of several thousand tons of amblygonite has been reported from the mines of this area.

Triphylite in nodules weighing hundreds of pounds has been obtained from the Lost Bonanza (now Mica King) and the Dyke lode, as well as from the Peerless and the Hugo.

Lepidolite is important only at the Peerless and the Bob Ingersoll. Micaceous aggregates several feet thick are common, one of the largest measuring 2½ by 5 by 6 feet.

CALIFORNIA.

The structural ridge of the extreme southern part of California is the north end of the Peninsular Range, which reaches its maximum size farther south in Lower California. To the east of the Peninsular Range, in California, lies the Colorado Desert; to the west, the coastal mesa. The Peninsular Range, at least in its northern part, is composed largely of igneous rocks, of which a granitic rock consisting of quartz, orthoclase, plagioclase, biotite, and hornblende, shows the greatest development in San Diego County. Into this rock are intruded bosses of a plagioclase-hornblende rock showing affinities to gabbro. In this gabbro are numerous pegmatite dikes, which strike northwest and dip southwest, whose outcrops extend for thousands of feet, and which range from a foot to 20 feet in thickness, as a rule, though a few are notably thicker. These dikes occur abundantly at Pala, San Diego County, as well as at numerous other localities. At Pala the pegmatites have been extensively exploited for their gem minerals, tourmaline (pink, red, green, blue), spodu-

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mene (lilac variety kunzite), and beryl, as well as for their lithium minerals, lepidolite and amblygonite. Although several tons of lepidolite have been obtained from other mines, the mineral has been commercially produced only from the Stewart mine, the first mine of the region to be found and developed. The mine is said to have been formerly located as a "marble" deposit (because of the compact light-gray lepidolite) and as a "cinnabar" deposit (because of the red tourmaline).

The Stewart mine is located on one of the largest pegmatite dikes of the region 1½ miles northeast of Pala. The bold outcrop of the white dike contrasts strongly with the dark gabbro rock that forms Stewart Mountain. The dike is about three-quarters of a mile long and has a thickness, at the mine, of about 60 feet. It dips about 15° W.

The pegmatite is coarse grained and is composed of much graphic granite, a granular quartz-feldspar rock, and large concentrations of nearly pure minerals, especially quartz. The lower part of the dike is a fine-grained rock composed chiefly of albite and quartz, with small amounts of muscovite and orthoclase. Lithium minerals, chiefly lepidolite, and pink and green tourmaline, appear in very small quantity throughout the greater extent of the dike but are concentrated in its southern part, in which the Stewart mine is located. These minerals lie in the middle part of the dike, above the fine-grained bottom rock and below the coarse-grained graphic granite and granular quartz-feldspar rock.

The lithium minerals at the Stewart mine are not confined to a single mass but, as exposed by the mining operations, form one large body more than 100 feet thick and at least six smaller bodies, one of which consists of amblygonite, the others of lepidolite. The largest mass of lepidolite seems to be lens-shaped and pitches toward the south. In the direction of the pitch the entire lens is about 90 feet long, and it has a maximum thickness of about 20 feet. It has been tunneled for 120 feet, and its length from east to west, when first exploited, was nearly 200 feet.

A part of the lens consists of nearly pure compact fine scaly lepidolite, with only a very small percentage of other minerals, mostly pink tourmaline, and some quartz and feldspar. A good portion of the lens contains more or less of the admixed minerals, forming a granular rock, of which the lepidolite probably does not constitute more than half. There is no sharp demarcation between the lens of the lepidolite and the normal pegmatite rock. On the other side of the normal pegmatite rock, as exposed in the tunnels, is a large mass of massive quartz, in which native bismuth has been found. This massive quartz also surrounded a lens of amblygonite, the nearest part of which was 20 feet away from the edge of the lepidolite lens. Several small nodules of amblygonite, as large as a man's hand, were encountered in the normal pegmatite between the main mass and the lepidolite lens. The main mass of amblygonite is lens shaped, pitching to the south and seeming to parallel the lepidolite lens in general shape and position. In June, 1904, the solid mass of pure amblygonite measured 25 feet (from north to south) by 12 feet (from east to west) and had a vertical thickness of at least 14 feet. It is reported that later developments have shown that the body of mineral is somewhat larger. Each of the other isolated bodies of lepi-

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dolite is several feet thick and would yield material averaging about half lepidolite.

Mining operations are very simple, as the tunnels are run in to the lepidolite, which is blasted out, rolled down the hill, and shipped without further treatment. Little foreign or dead material has to be removed.

OTHER LOCALITIES IN THE UNITED STATES.

The lithium minerals, lepidolite, amblygonite, spodumene, and triphylite, occur in several other parts of this country in addition to South Dakota and California. In Maine, Massachusetts, and Connecticut certain pegmatite dikes contain lithium minerals in abundance. A small quantity of spodumene was mined in 1889 in Massachusetts [1] for export, the mineral being abundant in pegmatite dikes near Huntington, Chester, Chesterfield, and Goshen. Enough lepidolite and amblygonite is encountered in mining for gems at Mount Mica, near Paris, Maine, to yield a small output of lithium. Considerable lepidolite is found near Canon City Colo.,[2] and a discovery of lepidolite and amblygonite near Dixon, N. Mex., has been reported to the Geological Survey.

FOREIGN LOCALITIES.

SWEDEN.

Two large vertical pegmatite dikes cut the iron-ore deposit (magnetite) at Uto, Sweden. The dikes consist mainly of petalite in coarse-grained to compact milk-white to gray, greenish, or reddish masses, and of quartz, lepidolite, and reddish feldspar. Associated minerals are red, green, and blue tourmalines, often in aggregates with lepidolite; large greenish-white tabular masses of spodumene in quartz; and several other minor pegmatite minerals, such as microlite and manganotantalite. The chemical element lithium was discovered in petalite from this mine. A considerable production of petalite for the extraction of lithium compounds has been reported, and an abundance of it still remains in the mine.

AUSTRIA AND GERMANY.

Outcropping on the summit of Mount Hradisko, in Moravia, a body of massive lepidolite 6 feet thick lies between a quartz-rich pegmatite and the quartz-poor gneiss that surrounds the pegmatite. The lepidolite is in scaly to compact masses, rarely in larger plates, associated with tourmaline (red, blue, green, and yellow), topaz, wolframite, cassiterite, apatite, and orthoclase.

In Bohemia and the neighboring part of Saxony the iron-lithium mica, zinnwaldite, occurs abundantly in veins and in greisen, associated with cassiterite. Before 1886 it was worked for its lithium content.

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[1] Emerson, B. K., Geology of old Hampshire County, Mass.: U. S. Geol. Survey Mon. 29, p. 326, 1898.
[2] Sterrett, D. B., Precious stones: U. S. Geol. Survey Mineral Resources, 1908, pt. 2, p. 844, 1909.

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FRANCE.

In the Central Plateau region of France pegmatites and lithium minerals are abundant at Montebras in Creuse, at Hureaux and Chanteloube in Haute-Vienne, and at several other places. At Montebras earlier excavations in the pegmatite were uncovered in 1859, and, as tin was doubtless the metal searched for, new excavations were extended downward for nearly 500 feet; but the search was abandoned in 1877 without much tin having been found. Amblygonite was encountered, and beginning with 1886 about 100 tons was produced annually for some years and used in the glass industry. The pegmatites containing cassiterite and amblygonite and abundant apatite form very irregular dikes in a granitic rock. The deposits also produce clay, feldspar, and quartz in commercial quantity.

AUSTRALIA.

Lithium minerals are reported [1] in sufficient abundance in Western Australia to supply the market. They are found in pegmatites around intrusive granite masses, and Simpson gives analyses of amblygonite, spodumene, and lepidolite, as well as of a lithium-bearing biotite.

SPAIN.

Amblygonite has been mined for a number of years at the San Finx tin mine in northwestern Spain. The reported production is shown in the table on page 17.

USES.

Lithium minerals are used as such but chiefly as sources of the different salts of lithium. Amblygonite and lepidolite are used directly in certain glasses, glazes, and enamels, the content of lithium and fluorine probably giving them special fluxing properties. Some lepidolite is also used directly in decorations and ornamentation, as in fireplaces. A small quantity was used in the reproduction of a gem mine at the San Diego Exposition in 1915 and 1916. Spodumene, when transparent, is used as a gem stone, the green (hiddenite) and lilac (kunzite) varieties having considerable value.

The most important use of manufactured lithium compounds is probably in certain storage batteries, in which the hydroxide (LiOH) finds special application. The medical use of lithium salts has greatly declined, as their effectiveness has been questioned and synthetic coal-tar products have superseded them. The carbonate, phosphate, citrate, and other organic combinations of lithium have been used in medicine chiefly for removing pathologic deposits of uric acid in the body, being administered as tablets or in solution as "lithia water." The bromide and the iodide are used in photography, and the cyanide in Roentgen-ray experiments. The chloride finds some application in fireworks, and the carbonate, mixed with carmine, is used as a staining nucleus. The chemical products derived from lithium minerals have also found application in military affairs.

[1] Simpson, E. S., The rare metals and their distribution in Western Australia: Nat. Hist. and Sci. Soc. Western Australia Jour., vol. 4, 1912.

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PRODUCTION.

The following table shows the production of lithium minerals for the United States and for Spain. The San Finx mine, in Spain, is the only foreign locality for which figures of production for consecutive years are available. In addition to the figures shown, France produced 47 short tons, valued at $4,420, in 1900, and Australia produced 46 short tons, valued at $993, in 1906.

Lithium minerals produced, 1889–1916.[a]

Year.	United States.		Spain.		Year.	United States.		Spain.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.		Quantity (short tons).	Value.	Quantity (short tons).	Value.
1889	[b] 30	[b] $450	.....	.....	1907	530	$11,000	0	0
1891	[b] 30	[b] 750	.....	.....	1908	203	1,550	110	$584
1898	[b] 30	[b] 750	.....	.....	1909	189	1,890	0	0
1899	[b] 210	[b] 3,500	.....	.....	1910	238	2,380	0	0
1900	520	[b] 9,500	.....	.....	1911	500	9,000	0	0
1901	1,750	43,200	.....	.....	1912	360	6,800	33	[b] 175
1902	1,245	25,750	.....	.....	1913	530	14,900	0	0
1903	1,155	23,425	19	$100	1914	525	8,000	33	[b] 175
1904	577	5,155	99	347	1915	486	9,867	110	[b] 584
1905	79	1,412	132	467	1916	619	12,035	.....	.....
1906	383	7,411	231	818					

[a] The statistics for the United States, from 1907 to 1916 were collected and compiled by Miss A. T. Coons.
[b] Estimated.

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ASBESTOS.

By J. S. DILLER.

PRODUCTION.

The asbestos industry of the United States is in good condition as to both production and manufacture. The output of raw material in this country is far less than the demand, but the needed supply is readily drawn from Canada. The supply of asbestos of all grades in Quebec is so large, so conveniently obtained, and of a quality so excellent as to delay the development of asbestos deposits in the United States, except as to the lowest grade, which will not bear transportation, and as to the highest grade, the domestic supply of which for certain purposes is superior to the best grade of asbestos from Canada. The demand for high-grade asbestos has always been active, but under the stimulus of war conditions the available supply is not equal to the demand.

The marketed production of asbestos in the United States in 1916 was 1,479 short tons, valued at $448,214. As compared with the production of 1915, this was a decrease of 252 tons, or nearly 15 per cent, in quantity but a gain of 482 per cent in value. The decrease in quantity was wholly in the lower grade. The output of higher grades increased both in quantity and in value.

Five States now produce asbestos—Arizona, California, Idaho, Georgia, and Virginia. Arizona and Georgia produce the largest quantities, Arizona of high-grade fiber and Georgia of fiber below the spinning grade. In Arizona there were three producers, but in each of the other States there was only one producer in 1916.

ASBESTOS IN THE UNITED STATES.

ARIZONA.

Arizona has become an important producing State on account of both the quantity and the quality of its asbestos. Production began in 1915, but it was not until 1916 that the output became considerable. Large consumers of asbestos in the United States, who are themselves owners and large producers of asbestos in Canada, have recently become the principal producers in Arizona, and that fact alone is proof of their confidence in the asbestos industry of that region. There were three producers during the last part of 1916, the principal production being on Ash Creek, near Salt River, about 40 miles northeast of Globe, where asbestos mining began in 1915. It has since extended northward beyond Salt River in the Sierra Ancha.

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Asbestos was first discovered in Arizona in the Grand Canyon but at such depth as to make asbestos mining and transportation to railroad a matter of great difficulty, and thus far the industry has not developed in that region.

The asbestos of Arizona is chrysotile and occurs in serpentine associated with limestone altered by intrusions of diabase. As the strata are nearly horizontal, they are for the most part best exposed on the sides of canyons. The cross-fiber veins of chrysotile are commonly parallel to the bedding of the limestone but are very irregular in their distribution, a fact resulting from the irregularity of the contact between the limestone and the intruding diabase. The asbestos has to be won by tunneling into the canyon wall. As the quantity of asbestos at any one place is small, the cost of production is high, but in mining the best grade much valuable short-fiber material is accumulated on the dump and is available for future milling.

Arizona asbestos is classified as fine, soft, silky, spinning fiber of first-class textile quality and as harsh fiber not suitable for textile manufacture. Although the second grade may have great length it is harsh and brittle and when put through textile processes creates a good deal of "splint," which makes a rough-looking yarn altogether unsuited for higher textile uses. Both grades may occur in the same mine. The lower grade appears to be the more abundant. The small percentage of iron contained in the best grade of Arizona fiber compared with Canadian fiber makes the Arizona asbestos especially useful for electric insulation. The limits of the asbestos field of Arizona are not yet known. The output will probably never be large compared with that of Canada, but under proper management the deposits may yield, say, 1,000 tons of valuable fiber annually for years to come.

CALIFORNIA.

The Klamath Mountains, the Coast Range, and the Sierra Nevada, in California, are rich in serpentine, and in places this rock contains considerable asbestos. The only production in California in 1916 was on Mears Creek, near Sims, in Shasta County, from which three carloads were shipped to an asbestos factory in Oakland. There is no fiber of spinning grade at this locality, and as the demand for the fiber mined is small the mining operations have not been extensive. The mine is within a few miles of the Southern Pacific Co.'s main line, and good water power for milling the fiber is available in Mears Creek. The serpentine is cut by a variety of dikes in the vicinity of the asbestos deposits. Cross-fiber veins of asbestos half an inch or less in thickness are common, and a prominent vein of slip fiber occurs on the same slope. There is considerable asbestos near the head of Mears Creek, and if there were a large demand for the lower grades of fiber a mill on this stream could do much toward meeting it.

Other prospects of asbestos in California that have attracted attention occur in Napa County near Canyon station, on the stage road from Napa to Monticello; in Placer County near Towle and Iowa Hill; in Amador County on Sutter Creek, 2½ miles east of Ione; in Calaveras County near Valley Spring; in Fresno County, 27 miles northwest of Coalinga; and in Riverside County at a point accessible by wagon road, but approximately 30 miles from a railroad, at an altitude of 4,500 feet. The general appearance of the fiber is rather

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promising, but when subjected to a regular fiberizing process by one of the large asbestos manufacturers it was reported to be brittle and to yield practically a powder instead of spinning fiber.

IDAHO.

In the vicinity of Kamiah, Lewis County, there are rocks made up wholly of asbestos arranged in fibrous bundles. The fibers are short and brittle and are consequently far below spinning grade and suited only for use as a filler in the manufacture of heat-resisting or fireproofing covers, cements, or paints. There is only one producer at present. The demand is small, but the supply of asbestos is large and the material is easily quarried, as it constitutes the whole mass of the rock. The occurrence is within a few miles of a railroad, 186 miles southeast of Spokane.

GEORGIA.

The asbestos mine near Sall Mountain, Ga., with a mill at Gainesville, has for years been the largest producer of asbestos in the United States. The asbestos, like that of Kamiah, Idaho, is of the mass-fiber type of anthophyllite, which forms fibrous bundles and constitutes the whole mass of the rock. Only the surface portion of the rock mass, which has been softened by weathering, is milled for fiber. The solid, unweathered portion of the rock is too hard for milling, and unless some way can be found to treat this portion successfully this limitation will greatly reduce the reserve for future needs. Georgia is far south of the glacier-swept region and the mantle of residual softened rock is unusually deep, so that there still seems to be a fairly good supply for the near future.

VIRGINIA.

Rocks similar to those that furnish the asbestos in Georgia are common in the mountain region of North Carolina and Virginia, and in the latter State there is a very small production of asbestos used in manufacturing a dental product.

VERMONT.

The country rocks of the asbestos deposits in Quebec, Canada, extend southwestward into Vermont, where they contain considerable bodies of chrysotile that was mined more or less successfully a few years ago. The Vermont area contains very little spinning fiber, but it is now attracting much attention. No production has recently been made. Although in the production of chrysotile asbestos Vermont can not compete successfully with Canada, the material in Vermont should be regarded as a valuable reserve if the Canadian deposits were not available.

WYOMING.

The asbestos deposits of Wyoming are largely chrysotile, but they contain only a trace here and there of fair spinning fiber. They have attracted much attention for years, especially from the promoters' point of view, but have not yielded a production. The possibilities of the region are not yet fully known. They should be tested and

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developed by experienced manufacturers of asbestos who need raw material. There is no doubt that a large quantity of mill fiber of good grade occurs in that part of the country, including the Laramie, Wind River, and Big Horn mountains, which is so situated with reference both to the transcontinental and to the Great Lakes and Gulf traffic as to be readily accessible.

SUMMARY.

With a view to increasing the available domestic supply of asbestos, especially of the spinning grades that are so much in demand, all areas of peridotite and pyroxenite rocks more or less altered to serpentine should be prospected for cross-fiber veins in which the fibers are three-quarters of an inch or more in length. The content of such fiber necessary to yield a profit may be less than 1 per cent of the rock quarried, and in obtaining it a much larger percentage of mill fiber will most probably be taken out.

Although the Arizona chrysotile fiber is excellent for certain purposes and finds a ready sale to those who need it for electric insulation, its mode of occurrence necessitates expensive operation and small production and it should be mined with especial reference to avoiding waste.

The origin of asbestos, especially of the Arizona fiber, is not well understood, and much field investigation is needed to discover the causes determining its distribution and the best methods of mining it so as to utilize as far as possible all the available grades.

The United States, being the largest manufacturer of asbestos and having only a meager domestic supply, has to depend very largely upon imported asbestos, but fortunately the chief source, Canada, is close at hand. Under increased demand the output of the United States is likely to be greatly augmented, although it can hardly be expected ever to supply all the asbestos needed for increasing manufacture.

ASBESTOS IN QUEBEC, CANADA.[1]

The asbestos mines of Quebec, which furnish most of the asbestos manufactured in the United States, were extremely active throughout 1916. The shipments amounted to 133,339 tons, valued at $5,182,905, of which quantity 114,978 tons, or 86 per cent, went to the United States. The market could have absorbed much more asbestos than was offered, but the output was limited by the shortage of labor. As the demand was greater than the offer, the prices rose accordingly, especially for the higher grades, and consequently, although the shipments in 1916 showed an advance of only 18 per cent, as compared with 1915, the value increased 46 per cent. This is reflected in the average price per ton, which was $38.87 in 1916, $31.33 in 1915, $26.96 in 1914, and $28.04 in 1913.

PRICES.

The extraordinary conditions of 1916 have again caused an advance of prices of asbestos in comparison with former years. By reason of car shortage and for other causes, some of the high-grade asbestos was sold at rates far above the regular trade prices quoted.

[1] Canadian Min. Jour., Mar. 15, 1917.

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Range of New York prices per short ton for Canadian chrysotile fiber, 1912–1916.

	1912	1913	1914	1915	1916
No. 1 crude	$300–$325	$320–$350	$350–$375	$350–$400	$350–$1,250
No. 2 crude	175– 200	200– 225	225– 250	225– 275	250– 900
No. 1 fiber		100– 125	100– 125	110– 150	150– 350
No. 2 fiber		75– 100	75– 100	80– 125	75– 150
Shorter fibers		10– 30	10– 30	10– 30	15– 60

Under pressure of shortage of material in 1916 Arizona spinning fiber sold from $500 to $1,000 a short ton.

IMPORTS.

The total imports of unmanufactured asbestos in 1916 were 116,162 short tons, an increase of 24 per cent on the imports in 1915 and nearly 79 times the production in the United States in 1916. The greatest increase was from Canada, although there was a larger proportionate increase in the imports from England. The imports from British South Africa are at least in part perhaps wholly crocidolite, blue asbestos, and possibly much or all of the asbestos reaching the United States by way of England is from the same source. The use of blue asbestos is growing in the United States, especially for electric welding. Most of the manufactured asbestos came from England. Imports from Germany and Austria-Hungary, although large in 1915, practically ceased in 1916 and were replaced in considerable measure by manufactured asbestos from France, Colombia, and Japan.

Asbestos imported into the United States in 1915 and 1916.[a]

Country.	1915			1916		
	Unmanufactured.		Manufactured.	Unmanufactured.		Manufactured.
	Quantity (short tons).	Value.		Quantity (short tons).	Value.	
Austria-Hungary			$10,502			
British South Africa				112	$10,625	
Canada	93,565	$1,980,749	1,867	114,978	3,069,617	$1,841
Colombia						109
Cuba			538			
Denmark			49			
England			106,412	1,072	223,228	119,123
France			139			10,762
Germany	1	734	14,117			100
Japan						298
Italy			2,624			2,538
Netherlands			190			
Scotland			879			293
	93,566	1,981,483	137,317	116,162	3,303,470	135,064

[a] Statistics furnished by the Bureau of Foreign and Domestic Commerce, Department of Commerce.

NOTABLE RECENT PUBLICATIONS CONCERNING ASBESTOS.

DILLINGHAM, C. K., Mineral yarn, paper read before the Philadelphia Textile School Alumni Association. (The paper is presented in abstract in the Textile World Journal, New York, May 27, 1916.)

The commercial yarns of asbestos in common use measure from 400 to 4,000 yards to the pound and may be made either entirely of asbestos fiber or with a proportion

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of cotton or with strands of brass or copper wire, which add strength to the yarn. The finer yarns are used for weaving insulating tapes that vary in thickness, it is said, from one-sixteenth to fifteen one-thousandths of an inch.

LONDON CHAMBER OF COMMERCE JOURNAL (Jan., 1917, p. 11) publishes an account of South African asbestos, which is blue (or crocidolite) asbestos. It occurs in the Asbestos mountains in three districts, Kuruman, Hay, and Prieska. Together these three districts constitute, according to the Government mining engineer, the largest asbestos-bearing area in the world. Prospecting has so advanced as to indicate that the asbestos may be profitably mined not only by surface workings, as in Canada and Russia, but also by underground methods, as in Arizona.

White asbestos (chrysotile) and blue asbestos (crocidolite) are competing for favor in the world market. It is claimed that the blue asbestos is lighter, longer, stronger, finer, and more elastic than chrysotile. The best blue asbestos has realized £45 to £65 a ton on the European market. A small quantity of it is imported into the United States, where, on account of its large iron content and its low fusibility, it appears to be used for electric welding.

TABER, STEPHEN, The genesis of asbestos and asbestiform minerals: Am. Inst. Min. Eng. Bull., Nov., 1916, pp. 1973–1998. Published in part also in Acad. Sci. Proc., Dec., 1916, pp. 659–664.

After considering asbestiform minerals, their chemical and mineralogical relations, as well as their physical properties, the author takes up the origin of fibrous structure, a problem to the solution of which he has brought the results of a series of laboratory experiments leading to the conclusion that "all cross-fiber veins are formed through a process of lateral secretion, the growing veins making room for themselves by pushing apart the inclosing walls, and that the fibrous structure is to be attributed largely to the physical conditions which have limited crystal growth to a single direction. In the case of asbestiform minerals, the fibrous structure is accentuated by a normal prismatic habit and cleavage." The paper is discussed by J. C. Branner, John A. Dresser, R. P. D. Graham, and George P. Merrill in Am. Inst. Min. Eng. Bull., Mar., 1917, pp. 397–405.

GRAHAM, R. P. D., Origin of massive serpentine and chrysotile asbestos, Black Lake-Thetford area, Quebec: Econ. Geology, Feb.–Mar., 1917, pp. 154–202.

The problems are considered from general as well as special chemical points of view. The nature, operation, and source of the reagents producing the metamorphism are fully discussed and the changes, with attendant phenomena, are described. The author adopts the view of Dresser and remarks that "it is probably safe to say the weight of modern opinion is in favor of the hypothesis that chrysotile has been formed in situ by direct replacement of the massive serpentine," a view he subsequently maintained (Am. Inst. Min. Eng. Bull., Mar., 1917, pp. 401–402) in discussing Stephen Taber's paper noted above.

MINING MAGAZINE, Asbestos manufacturers in Canada (Oct. 1916, p. 236): "The associated boards of trade of the eastern Township of the Province of Quebec, Canada, have adopted a resolution urging the Quebec government to enforce the utilization of the asbestos produced in the Province in home manufacture and to prevent its wholesale export as at present. The Canadian Mining Institute, in its August bulletin, advises caution in the consideration of such a policy." Canada, at present, is the principal source of the world's supply of asbestos, but there is no reason to suppose that it would be able to maintain that advantage if restrictions were enforced. Manufacturers, instead of being forced to erect plants in Canada, would seek asbestos elsewhere—in Russia, South Africa, Cyprus, and Italy. The article contains an instructive review of the interdependence of these points of production.

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TALC AND SOAPSTONE.

By J. S. DILLER.

TALC.

PRODUCTION.

Talc and soapstone are frequently regarded in ordinary language as practically synonymous, but they differ. Talc is a mineral. Soapstone is a massive rock composed largely of talc. Although closely related, commercial talc and soapstone differ so much as to their source and use that they are considered in this report under separate headings.

Chemically, talc is an acid metasilicate of magnesium, remarkable for its softness, soapy feel, difficult fusibility, insolubility in ordinary acids, and low electric conductivity. These properties make it one of the most stable and unchangeable of minerals, and therefore one of the best means of protection against changes in temperature or other conditions. On this account talc is one of the most useful minerals, and it is gratifying to know that the United States produces and uses more talc than any other country in the world. In 1916 the production and manufacture of talc was greater than ever before.

The sales of talc in 1916 amounted to 193,309 tons, valued at $1,762,842, a gain, as compared with 1915, of 16 per cent in quantity and of about 26 per cent in value.

Ten producing States reported to the Geological Survey, but as New Jersey, Massachusetts, and Maryland had only one producer each the figures for these States are combined with those for other States to avoid disclosing individual production.

Talc sold in the United States in 1915 and 1916.

State.	1915		1916	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
New York	88,214	$864,843	93,236	$961,510
Vermont	61,997	406,652	73,215	501,175
Pennsylvania and New Jersey	7,989	56,466	8,222	59,331
Virginia	3,036	18,579	8,798	73,622
Georgia and Massachusetts	2,934	25,971	6,921	111,686
North Carolina	1,454	21,501	1,787	41,824
California and Maryland	[a]712	[a]7,185	1,130	13,694
	166,336	1,401,197	193,309	1,762,842

[a] California only.

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New York has always been the leading producer, and its output is steadily increasing. Talc mined in New York is especially good for paper filler and is largely used for that purpose, although much goes into paints. The yield of Vermont has greatly increased in late years, and its output in 1916 was not quite four times that of all the other States except New York. Much of the talc of Vermont goes into paper, but some is used for foundry facing, for rubber goods, and in coating walls. A small quantity is used for crayons.

As noted in the following table, talc is marketed in three forms. About 5 per cent is sold rough as it comes from the quarry or mine in California, Georgia, Maryland, North Carolina, Pennsylvania, and Virginia; a small quantity is manufactured; and the bulk is ground and sold for various purposes.

Classification of talc sold in the United States in 1916.

Condition in which marketed.	Quantity (short tons).	Value.	Average price per ton.
Rough	11,299	$106,928	$9.46
Manufactured into pencils and blanks [a]	828	102,674	124.00
Ground [b]	181,182	1,553,240	8.57
	193,309	1,762,842	9.12

[a] Includes slate pencils and metal workers' crayons and blanks used in making acetylene burners and other objects.

[b] For foundry facings, filler for paper, paint, and rubber goods, toilet powder, foot ease, lubricators for dressing skins and leather, etc.

The material cut into pencils and blanks is much the best and most expensive grade of talc. Less than 0.5 per cent of all that is mined in the United States belongs to this class. The greater portion of it comes from Georgia and is manufactured at Chattanooga, Tenn. A considerable proportion comes from North Carolina. A small quantity of talc of pencil grade was mined in Vermont in 1916, the first production yet reported from New England.

Although the war has greatly stimulated production it has not greatly increased prices, except for special products.

IMPORTS.

Although the quantity of talc imported for consumption has varied from year to year, it has on the whole increased gradually from 4,000 short tons in 1905 to 18,882 tons in 1916. During the latter year about one-tenth as much talc was imported as was produced in the United States.

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Talc imported for consumption in the United States, 1915–16.[a]

Kind.	1915		1916		
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Average price per ton.
Crude and unground steatite and French chalk[b]	2,117	$12,967	2,027	$12,645	$6.24
Ground talc, or steatite cut, powdered, washed, or pulverized[c]	15,952	186,873	16,855	218,230	12.95
	18,069	199,840	18,882	230,875	12.34

[a] Statistics furnished by the Bureau of Foreign and Domestic Commerce, Department of Commerce.
[b] Duty free.
[c] 15 per cent duty.

General imports of talc, ground or manufactured, into the United States, 1915 and 1916.[a]

Country.	1915		1916		
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Average price per ton.
Austria-Hungary	138	$3,019			
British South Africa			10	$124	$12.40
Canada	4,797	57,961	5,964	75,029	12.58
England			1	38	38.00
France	3,734	19,253	3,570	20,791	5.82
Germany	8	1,888			
Italy	7,268	104,403	7,105	121,254	17.07
Spain			11	400	36.36
Sweden			22	544	24.73
	15,945	186,524	16,683	218,180	13.08

[a] Statistics compiled from records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

The general imports of talc in 1916 showed an increase of 5 per cent in quantity and of 17 per cent in value as compared with the corresponding imports in 1915. Italy is our chief foreign source of supply for toilet use. That from Canada is also of good grade. France ranks third as a foreign source but produces apparently a cheaper grade. The higher grades of material for cutting come from Sweden, Spain, and from India through England. Much of the material imported from India is of gas-burner grade. The output of India in 1913 was 2,524 tons, but in 1914 it was only 999 tons. The resources of this grade in India are large.

SOAPSTONE.

Soapstone is a massive rock so rich in talc as to have a soapy feel. It is more extensively quarried and used in the United States than in any other country. Its most important application, depending on its resistance to heat, acids, and electricity, is in the manufacture of laundry tubs, laboratory table tops, tanks, sinks, fume hoods, and switchboards and in general insulation, besides many smaller uses growing out of its slow radiation of heat. There was a small production of soapstone in California and in Rhode Island, but almost the entire output of the United States came from Virginia, where there were four producing quarries. The total yield, including that of California, is 19,652 short tons.

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Soapstone is marketed in three forms—(1) rough or crude, in large blocks, as it comes from the quarries; (2) sawed into slabs for the use of manufacturers; and (3) as manufactured objects, such as firebricks, foot warmers, and griddles.

Classification and value of soapstone mined and sold in the United States in 1916.

Class.	Quantity (short tons).	Value.	Average price per ton.
Crude	525	$1,355	$2.58
Sawed into slabs	3,558	72,501	20.38
Manufactured	15,569	417,105	26.79

The soapstone in Virginia is obtained from a large belt of intrusive rocks extending in a northeast direction through Nelson, Albemarle, and Orange counties. This large intrusive mass will afford a great source of supply for many years. It is near the Southern and other railroads, as well as James River, and within easy reach of Chesapeake Bay, so that adequate facilities for transportation are available.

CONCLUSION.

The United States has large reserves of talc and soapstone and, except for certain grades of talc, can with added labor greatly increase its output. More searching field investigations would doubtless discover resources that would serve to increase the domestic output of pencil and gas-burner grades as well as of best toilet powder. The "footease" grade of ground talc, now so extensively used in the army, may be fully supplied in this country. In 1916 the general imports of ground talc were less than 9 per cent of the domestic production, and more than one-third of the imports came from Canada.

NOTABLE RECENT PUBLICATIONS.

JACOBS, E. C., The talc and serpentine deposits: In Vermont State geologist Tenth Rept., pp. 232–429, 1915–16. A map of the State shows the distribution of the deposits of talc and of the associated formations. The report describes the deposits, their mining development, production, economic importance, and probable origin.

HEWITT, F. R., Methods of mining talc: Am. Inst. Min. Eng. Trans., Arizona Meeting, pp. 1371–1372, September, 1916. The method described is that practiced at Hewitts, N. C., where high-grade talc is mined chiefly for crayons and blanks for gas burners and electrical works.

BUREAU OF FOREIGN AND DOMESTIC COMMERCE, Department of Commerce. Commerce Reports, December 20, 1916, states that "Deposits of talc and kaolin are of frequent occurrence in crystalline rocks, which are of wide distribution in Brazil. Some of these, more favorably situated in relation to transportation and markets, are now being worked. Of these, the following may be mentioned:

"1. Near Rezende, State of Rio de Janeiro, where a very pure white talc is produced, requiring little treatment before being available as a cosmetic.

"2. Near Lorena, State of Sao Paulo.

"3. Near Santo Amaro, State of Sao Paulo, not far from the city of Sao Paulo.

"Massive talc, or steatite, occurs in different parts of the country, as near Itaberaba, municipio de Ouro Preto, Varzea near Dores de Boa Esperança, and near Jacuhy in the western part of Minas Geraes. At these places its principal use is in the manufacture of cooking utensils, which are turned out on the lathe from the solid block of soapstone. Pans and pots of this material are specially prized in Brazil for cooking rice. It also occurs in Ceara and Goyaz."

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PHOSPHATE ROCK.[1]

By R. W. STONE.

OCCURRENCE AND USES.

Phosphate rock is a sedimentary deposit containing phosphate of lime. It occurs as a hard rock in beds that lie between beds of sandstone, shale, or other sedimentary rock; as pebbles in stream deposits; and as a residuum from the decomposition of phosphatic dolomite, limestone, and other rocks containing phosphate. The method of mining it depends on the character of the deposit.

Phosphate rock is finely ground and used directly as fertilizer, and as an ingredient of artificial fertilizers. Its content of phosphoric acid is also incorporated into certain chemicals.

Phosphate rock occurs in commercial quantity in several countries in both the Eastern and the Western hemispheres. The annual production in the United States has been approximately one-half the world's production.

PRODUCTION.

PHOSPHATE ROCK SOLD.

The quantity of phosphate rock marketed in the United States in 1916 was 1,982,385 long tons, valued at $5,896,993, an increase of 146,718 tons in quantity and of $483,544 in value over the production of 1915. This increase was comparatively small, but it indicates an improvement in the industry, and suggests that in spite of the curtailment in the exports the production of former years may in time be approached. The output in 1916 was less than two-thirds that in 1913, the year before the European war began.

The total quantity of phosphate rock sold in the United States from the beginning of the industry in 1867 to 1916, inclusive, is 52,275,958 long tons, valued at $206,723,164. The production for the last 10 years is shown in the following table:

Phosphate rock sold in the United States, 1907–1916.

Year.	Quantity (long tons).	Value.	Year.	Quantity (long tons).	Value.
1907	2,265,343	$10,653,558	1912	2,973,332	$11,675,774
1908	2,386,138	11,399,124	1913	3,111,221	11,796,231
1909	2,338,264	10,796,456	1914	2,734,043	9,608,041
1910	2,654,988	10,917,000	1915	1,835,667	5,413,449
1911	3,053,279	11,900,693	1916	1,982,385	5,896,993

[1] The statistical tables in this chapter, except those showing imports and exports, were prepared by Miss L. M. Jones, of the United States Geological Survey, whose careful scrutiny and criticism of the returns from producers contributed largely to the accuracy and completeness of the report.

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An increase in the use of phosphate rock would benefit the individual phosphate producer and also the Nation by reason of increased productivity of the soil. The method of application of phosphate to the soil, however, whether as raw ground rock or as superphosphate, is a subject beyond the province of the Geological Survey, whose interest lies more in the increase of production than in the method of consumption. In order to increase the domestic consumption of phosphate rock it is necessary to convince farmers of the profit in applying phosphoric acid to their lands. Fertilizer manufacturers and State agricultural experiment stations have long been directing their efforts to this end by urging the use of acid phosphate or "complete" commercial fertilizers, or of fine-ground natural-rock phosphate.

PHOSPHATE ROCK MINED.

The quantity of phosphate rock mined in any year is not the same as that sold, for the quantity in stock at the mines at the end of the year is variable. The quantity mined in 1916 was 2,169,149 tons. Compared with the quantity mined in 1915, which was 1,935,341 tons, this was an increase of 12 per cent, as against a decrease of about 27 per cent in 1915 from 1914. In Florida the increase was about 17 per cent, 24 companies operating in 1916 instead of 17, as in 1915. In South Carolina there was a decrease of 46 per cent, and in Tennessee an increase of 5 per cent. In Kentucky 1 producer reported rock mined. The production in the Western States decreased 55 per cent.

STOCKS.

Stock on hand at the close of 1916 showed an increase for the entire country of 20 per cent, the total stocks being well over 1,000,000 tons. In Florida the increase was nearly 23 per cent and in Tennessee it was nearly 15 per cent. In South Carolina, however, the stock on hand decreased 61 per cent.

PRODUCTION BY STATES.

CONDITIONS AND OUTPUT.

The phosphate industry in Florida was in a bad condition in 1916, but not so bad as in 1915. In South Carolina it was much worse than it had been for many years. In Tennessee the industry showed a strong recovery, but it had suffered from the effects of the European war much less than in Florida and South Carolina. Shipments of domestic phosphate rock to Europe, which fell off greatly in 1915, were even less in 1916.

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Phosphate rock sold in the United States, 1915–1916.

State.	1915			1916		
	Quantity (long tons).	Value.	Average price per ton.	Quantity (long tons).	Value.	Average price per ton.
Florida:						
Hard rock	50,130	$265,738	$5.30	[a] 47,087	$295,755	$6.28
Land pebble	1,308,481	3,496,501	2.67	1,468,758	3,874,410	2.64
	1,358,611	3,762,239	2.77	1,515,845	4,170,165	2.75
South Carolina:						
Land rock	83,460	310,850	3.72	53,047	211,125	3.98
Tennessee:						
Brown rock	[b] 389,759	1,327,747	3.41	[c] 364,108	1,357,888	3.73
Blue rock				47,682	152,465	3.20
White rock				.....	.....	.....
	[b] 389,759	1,327,747	3.41	411,790	1,510,353	3.67
Western States	[d] 3,837	12,613	3.29	[d] 1,703	5,350	3.14
	1,835,667	5,413,449	2.95	1,982,385	5,896,993	2.97

[a] Includes several thousand tons of soft phosphate.
[b] Includes a very small quantity of rock from Arkansas.
[c] Includes a small quantity of brown rock from Kentucky.
[d] Includes, 1915: Idaho, Utah, and Wyoming; 1916: Utah and Wyoming.

FLORIDA.

In 1916 Florida, the leading State in the production of phosphate rock, marketed 1,515,845 long tons, valued at $4,170,165, or more than 76 per cent of all the phosphate rock produced in the United States. Compared with the output of 1915, this was an increase in quantity of 157,234 long tons, or 11 per cent, and in value of $407,926, or 10 per cent.

The hard rock phosphate, which is the variety most exported, was produced in even smaller quantity in 1916 than in 1915, when there was a decrease of 84 per cent. No river pebble was mined or sold in 1916. The increase of land pebble over the quantity sold in 1915 was 160,277 tons.

The price of land-pebble phosphate remained practically the same, but the price of hard-rock phosphate increased from $5.30 to $6.28 per ton. There were 7 shippers of hard-rock and 13 shippers of land-pebble phosphate.

Phosphate rock sold in Florida, 1912–1916.

Year.	Hard rock.		Land pebble.		Total.	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
1912	493,481	$3,293,168	[a] 1,913,418	$6,168,129	2,406,899	$9,461,297
1913	489,794	2,987,274	[a] 2,055,482	6,575,810	2,545,276	9,563,084
1914	309,689	1,912,197	[a] 1,829,202	5,442,547	2,138,891	7,354,744
1915	50,130	265,738	1,308,481	3,496,501	1,358,611	3,762,239
1916	[b] 47,087	295,755	1,468,758	3,874,410	1,515,845	4,170,165

[a] Includes a small quantity of river pebble.
[b] Includes several thousand tons of soft phosphate.

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SOUTH CAROLINA.

The phosphate rock mined in South Carolina in 1916 was land rock only and the production amounted to 53,047 long tons, valued at $211,125, a decrease of 30,413 tons, or 36 per cent, in quantity and of $99,725, or 32 per cent, in value. The average price per ton increased from $3.72 to $3.98.

Phosphate rock sold in South Carolina, 1912–1916.

Year.	Quantity (long tons).	Value.	Year.	Quantity (long tons).	Value.
1912	131,490	$524,760	1915	83,460	$310,850
1913	109,333	440,588	1916	53,047	211,125
1914	106,919	415,039			

TENNESSEE.

The production of phosphate rock in Tennessee in 1916 was 411,790 long tons, valued at $1,510,353. The output of the State was nearly 21 per cent of the entire production of the United States. It showed an increase of 22,031 long tons, or nearly 6 per cent, in quantity and of $182,606, or nearly 14 per cent, in value over the State's production in 1915. The average price per ton increased from $3.41 to $3.67. By far the larger quantity of phosphate quarried in Tennessee is brown rock, the total quantity of blue rock being less than 50,000 tons in 1916.

Phosphate rock sold in Tennessee, 1912–1916.

Year.	Brown rock.		Blue rock.		Total.	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
1912	359,692	$1,420,726	[a]63,639	$219,750	[a]423,331	$1,640,476
1913	[b]451,559	1,774,392	(b)	(b)	451,559	1,774,392
1914	[b]483,203	1,822,770	(b)	(b)	483,203	1,822,770
1915	[c]389,759	1,327,747	(b)	(b)	[c]389,759	1,327,747
1916	[d]364,108	1,357,888	47,682	152,465	[d]411,790	1,510,353

[a] Includes a small quantity of rock from Arkansas.
[b] Blue rock included with brown rock.
[c] Includes blue and white rock and a very small quantity of rock from Arkansas.
[d] Includes a small quantity of brown rock from Kentucky.

WESTERN STATES.

The phosphate rock produced in the Western States in 1916 came from Rich County, Utah, and Uinta County, Wyo. The western production is insignificant, amounting in 1916 to only 1,703 long tons, valued at $5,350, compared with 3,837 tons, valued at $12,613, in 1915. This output constituted about 0.08 per cent of that of the entire country. The average price per ton of western phosphate rock was $3.14, or 15 cents per ton less than in 1915.

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PHOSPHATE ROCK IN THE WESTERN STATES.

EXPLORATION AND DEVELOPMENT.

Systematic exploration and development of the phosphate deposits in the Western States was begun about 1904 and shipments were first made from Idaho in 1906 and from Utah and Wyoming in 1907. The United States Geological Survey began to examine the deposits in detail in 1909 and is still engaged in the work. The Survey's geologists have discovered enormous deposits of high-grade rock in Idaho, Utah, Wyoming, and Montana. Several detailed reports on the areas examined have been prepared and have been summarized by G. R. Mansfield,[1] of the United States Geological Survey. The following paragraphs are abstracted from that paper.

CHARACTER OF THE ROCK.

The phosphate of the western field is generally an even-bedded, gray to brown or black oolitic rock, which emits a fetid odor when struck with a hammer. Weathered surfaces have a light-bluish or white coating, commonly in reticulated pattern. This color generally identifies the rock to the prospector. Individual oolites range from microscopic size to a diameter of three-sixteenths of an inch and give the rock on some of its weathered surfaces the structure of fish roe. Larger nodules, which locally become numerous, reach an inch in diameter. The matrix is inconspicuous, fine grained, and less phosphatic than the oolites.

The phosphate beds throughout the four Western States appear to be true bedded deposits analogous to coal and retain their thickness and quality over wide areas. For these reasons they are regarded as original sedimentary deposits and it is assumed that they maintain at depth the characteristics they display at the surface.

DEPOSITS BY STATES.

UTAH.

The phosphate deposits of Utah occur at two horizons, in the upper Mississippian and in the Permian (?). The deposits in the upper Mississippian are in Rich and Cache counties. Beds near Logan, Cache County, are from 6 inches to 2½ feet thick and carry from 31 to 70 per cent of tricalcium phosphate. In Laketown Canyon, Rich County, there is a phosphate zone nearly 7 feet thick, and some of the material contains as much as 81.7 per cent of tricalcium phosphate. In the Oquirrh Range, 50 miles southwest of Salt Lake City, there is a deposit of phosphate rock that carries 67 to 75 per cent of tricalcium phosphate. The quantity available in these districts has not been determined.

In the Uinta region the beds of phosphate are 1 foot to 6 feet thick and contain up to 70 per cent of tricalcium phosphate. In the Ogden region some of the beds yield 39 to 62 per cent of tricalcium phosphate, and in Weber Canyon a single 13-foot bed has an average content of 46.1 per cent. In the Woodruff and Crawford mountains the main bed is usually 5 to 6 feet thick and contains 70 per cent of

[1] Mansfield, G. R., Phosphate resources of the United States: Second Pan Am. Sci. Cong. Proc., sec. 7, pp. 729–766, 1917.

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tricalcium phosphate. This area contains about 96,750,000 long tons of high-grade phosphate rock. No estimate can yet be made of the quantity in the other regions.

The great body of the western phosphate occurs in Permian (?) rocks, and rocks of this age are widely distributed through northeastern Utah. The Permian phosphate deposits are in Summit, Wasatch, Duchesne, and Uinta counties, along the northern and southern flanks of the Uinta Mountains, and to the north in Weber, Morgan, and Rich counties. They occur largely in public land which is at the disposal of the United States Government. The area in Utah reserved as workable phosphate land April 1, 1917, contains 302,465 acres.

IDAHO.

The known phosphate lands of Idaho lie in the southeastern part of the State, in Bear Lake, Bannock, Bingham, Bonneville, and Fremont counties. The Government has reserved 966,377 acres in Idaho as workable phosphate land, to which must be added 4,080 acres of officially classified phosphate land in the Fort Hall Indian Reservation. Idaho appears to contain the largest body of high-grade phosphate rock in the western field. In the Georgetown Canyon region there are three commercially workable beds, from 3 to 6 feet thick, that carry 72.9 to 82.3 per cent of tricalcium phosphate. The main bed throughout the Idaho district averages 5 or 6 feet in thickness and carries about 70 per cent of tricalcium phosphate. Estimates based on detailed studies indicate that the areas examined probably contain 5,200,000,000 long tons of tricalcium phosphate. These estimates include chiefly the main bed, which contains high-grade rock carrying 65 per cent or more of tricalcium phosphate; they do not include the thinner beds of high-grade rock nor the great body of low-grade material. Large areas of phosphate land have not yet been examined. Rock phosphate has been quarried and shipped from Montpelier, Bear Lake County.

WYOMING.

The phosphate lands of Wyoming are in their western part contiguous to those of Idaho, from which they extend eastward through several mountain ranges in Uinta, Lincoln, and Fremont counties as far as the Owl Creek Mountains. The Government has reserved in Wyoming as phosphate land 998,592 acres, and has officially classified as phosphate land 20,576 acres in the Wind River Indian Reservation, a total of 1,182,816 acres of phosphate land in this State.

The richest deposit reported in northwestern Wyoming is in the canyon of Snake River, 3 miles below the mouth of Fall River. Here, besides the main bed, 9 feet thick, a random sample from which yielded 68.5 per cent of tricalcium phosphate, there are several beds from 2 to 12 feet thick, carrying from 20 to 60 per cent of tricalcium phosphate. In southwestern Wyoming, in the Sublette Ridge, Beckwith Hills, and Cokeville areas, the phosphate is comparable in quality and thickness with the Idaho rock, though the thickness of the high-grade bed, containing 70 per cent or more of tricalcium phosphate, is less uniform, apparently ranging from about 3 to 5 feet.

In the Wind River and Owl Creek mountains there are two phosphate beds, one of which is persistent throughout both ranges, and

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the other—the lower one—is limited to the southeastern part of the Wind River Range. On the northeastern slope of the Wind River Mountains, near Lander, along a front of 30 miles the upper bed is 3 to 5 feet thick and contains 40 per cent or more of tricalcium phosphate; elsewhere it is of only slight prospective vlaue. In the same locality the lower bed across several townships is 2 to 4 feet thick and the content of tricalcium phosphate is 45 per cent or more.

The quantity of phosphate rock in the Wyoming fields is very great, though much of it is of medium or low grade. The Sublette Ridge, Beckwith Hills, and Cokeville areas are estimated to contain 37,200,000 tons of high-grade phosphate rock. It is not yet practicable to make estimates of the other fields. Rock has been shipped from Cokeville and Sage, Lincoln County.

MONTANA.

Phosphate deposits occur at several places in Beaverhead, Granite, Powell, and Silver Bow counties, Mont. Phosphate was first discovered in Montana at Melrose in 1910 by a Government geologist, but the field in that vicinity has not been described in detail. The phosphate areas most fully known are at Elliston, Garrison, and Philipsburg.

In the Elliston area the main phosphate bed is 3 to 6 feet thick and carries 61 to 72 per cent of tricalcium phosphate. The outcrop is about 12 miles long and the field contains about 86,000,000 tons of high-grade rock.

In the Garrison field the economically important part of the phosphate deposit lies east of Hoover Creek. The trace of the bed is about 18 miles long and is in the form of a fishhook. The bed is believed to average 4 feet in thickness and analyses show that it contains an average of at least 60 per cent of tricalcium phosphate. If 3,000 feet is assumed as the depth of profitable mining, the Garrison field contains at least 97,000,000 tons of available rock phosphate. This estimate does not include layers of lower-grade rock in the eastern part of the field, or the thin bed of rock phosphate or sandstone containing nodules of phosphate in the western part of the field.

In the Philipsburg field the phosphate bed is so poorly exposed that few details of its thickness and character have been obtained. The evidence at hand, however, indicates that where it has not been deteriorated by faults or similar deformation the deposit is comparable in size and quality to that of the eastern part of the Garrison field.

Near Melrose a bed of phosphate 6 feet thick averages about 65 per cent of tricalcium phosphate. About 8 miles of outcrop is known, but excavations have not been made to determine the thickness of the bed throughout this distance. Sufficient data are not at hand to permit an estimate of the quantity. The outstanding withdrawals of phosphate land in Montana April 1, 1917, were 119,327 acres.

SUMMARY.

The western phosphate field includes about 2,500,000 acres, in which there are about 5,750,000,000 tons of high-grade rock within minable depth (5,000 feet) of the surface, and in addition several

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billion tons of rock carrying from 15 to 40 per cent of tricalcium phosphate. Throughout most of the western field there is a main bed from 3 to 6 feet thick, which runs over 65 per cent in tricalcium phosphate. The workable deposits occur chiefly in public lands of the United States. The character and mode of occurrence of the rock are such that for the most part it must be mined by underground methods rather than by open pits. The rock can be ground and treated with acid, however, without the preliminary washing and drying which increase the cost of production of eastern phosphates.

In comparison with the preceding estimate of the quantity of high-grade phosphate rock the total production of the United States in the last 50 years, or since the beginning of the industry, is less than 1 per cent of the reserves known at the present time.

THE WORLD'S DEPOSITS.

WESTERN HEMISPHERE.

In the Western Hemisphere phosphate rock is produced in the United States, in Canada, the Dutch West Indies, French Guiana, and Chile.

NORTH AMERICA.

United States.—The principal deposits of phosphate rock in the United States are in Florida, South Carolina, Tennessee, Kentucky, Arkansas, Montana, Idaho, Wyoming, and Utah.

Canada.—The principal phosphatic rock in Canada is apatite, which occurs in workable quantity in two main districts—one in the Province of Ontario, the other in the Province of Quebec. The district in Ontario is 100 miles long and 75 miles wide, extending from St. Lawrence River northward toward Ottawa River over Addington, Frontenac, Lanark, Leeds, and Renfrew counties; the district in Quebec occupies a belt 15 miles wide, extending northward from Ottawa for an unknown distance. These deposits, which have been worked mainly by quarrying, are now practically abandoned. Rock phosphate occurs in a thin bed near Banff, Alberta, but is not used.

SOUTH AMERICA.

Dutch West Indies.—In Aruba and Curaçao, islands off the coast of Venezuela, there are deposits of phosphate rock which is mined in small quantity and shipped to Europe. It is reported that the output in 1914 was about 100,000 tons, averaging 85 to 90 per cent of calcium phosphate.

French Guiana.—Phosphate deposits occur on the island of Salut and on the Connetables, close to the coast of French Guiana. The rock is exported.

Chile.—A large, rich deposit of phosphate is reported to occur in the valley of Huasco River about 300 miles north of Valparaiso.

EASTERN HEMISPHERE.

In the Eastern Hemisphere phosphate rock is produced in Europe, Africa, and in the islands of the Indian and South Pacific oceans.

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EUROPE.

Belgium.—The high-grade phosphate deposits of Belgium are exhausted, only low-grade deposits remaining. The rock is found in layers and pockets, and carries between 25 and 65 per cent of bone phosphate.

France.—The principal deposits of France are in Somme and Oise. Workable deposits are nearly exhausted, only low-grade material remaining. There are low-grade deposits of a peculiar nature, not good enough for use as fertilizer, in Cambresis, Ardennes, Auxerre, and Burgundy. The French deposits are of higher grade than the Belgian, as they carry 50 to 80 per cent of bone phosphate. Deposits occur also in the Pyrenees Mountains.

Russia.—The phosphate deposits of Russia are in the Provinces of Moscow, Vladimir, and Kostroma, and on the Galician border in southeastern Russia.

Spain.—The only deposits worked extensively in Spain are at Aldea Moret, in the Province of Caceres.

Great Britain.—Low-grade phosphate in the form of beds of coprolite occurs in Cambridgeshire, Suffolk, and Bedfordshire, England, and in Montgomeryshire, Wales. The production has been very small.

AFRICA.

Tunis.—The principal deposits of phosphate rock in Tunis are the Gafsa fields, in the southern half of Tunisia. Tunis now produces more phosphate than any other foreign country, its annual output being between 1,500,000 and 2,000,000 tons.

Algeria.—The deposits of phosphate rock in Algeria are continuations of the deposits in Tunis. The two important mining districts are near the towns of Setif and Tebessa, in eastern Algeria. The production is over 500,000 tons a year, and the exported rock carries 58 to 68 per cent of lime phosphate.

Egypt.—Extensive deposits of phosphate occur in Egypt near the Red Sea. There are mines 20 miles from Port Safalga, and concessions 12 miles inland from Kosseir and also at Sebaia, on the eastern bank of the Nile between Keneh and Assouan. Beds of phosphate are found in other districts on both sides of the Nile Valley. Practically all the raw rock phosphate produced is shipped from Egypt, principally to Japan, and contains 65 per cent or more of tricalcium phosphate.

Natal.—Phosphates have been found in Natal near Weenen, Ladysmith, and Byrnetown. The rock is in the form of reefs and nodules. The percentage of tricalcium phosphate is too low for use in making superphosphates.

ISLANDS IN INDIAN AND SOUTH PACIFIC OCEANS.

Australia.—Near Clinton, South Australia, there are pockety deposits without regular stratification and of varying quality.

New Zealand.—In the Otago district near Clarendon, New Zealand, there are beds of phosphate 3 to 12 feet thick resting in pockets in limestone.

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Christmas Island (Straits Settlements).—On Christmas Island, which lies in the Indian Ocean 190 miles south of Java, rock carrying 80 per cent of bone phosphate is quarried and shipped to Australia and Japan.

Ocean Island.—On Ocean Island, in Gilbert Archipelago, east of New Guinea, there are deposits of rock phosphate similar to that at Christmas Island—high in calcium phosphate and low in iron and alumina.

Other deposits.—Phosphate rock of high grade is reported also on Angaur Island in the Pelew group, and on Maketea near Tahiti, in the Society Islands.

IMPORTS OF FERTILIZER MATERIALS.

The fertilizer materials imported into the United States in 1916 included many compounds containing phosphorus, nitrogen, and potash. Those containing phosphorus include bone ash, guano, basic slag, and crude phosphate rock. The potash fertilizers include various potash salts, kainite, manure salts, and double-manure salts. The nitrogen compounds are chiefly cyanamid, nitrates, and ammonium salts.

The quantity of calcium cyanamid, or lime nitrogen, used in the United States has increased from 5,000 tons in 1911 to 40,000 tons in 1916. It is a bluish-black odorless powder containing 20 to 22 per cent of nitrogen. The plants of the American Cyanamid Co., which manufactures it, are at Niagara Falls, Canada. It is used by more than 300 manufacturers of fertilizer in the United States, and is now a source of organic nitrogen in about one-fourth of the total ammoniated fertilizers consumed in the country.

Fertilizers imported and entered for consumption in the United States, 1912–1916.[a]

Fertilizer.	1912		1913		1914		1915		1916	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
Apatite	100	$1,400	2,962	$22,471	20	$300	.....	.....	.....	.....
Bone dust or animal carbon, and bone ash, fit only for fertilizing	117,717	878,686	35,012	851,136	36,000	892,529	21,538	$543,243	18,117	$485,737
Calcium cyanamid or lime nitrogen	9,311	493,519	26,729	1,410,248	21,793	1,119,785	30,043	1,322,195	40,516	1,755,644
Guano	19,128	329,624	16,674	518,429	25,335	761,562	9,874	220,768	12,992	878,036
Kainit	511,976	2,386,362	465,336	2,201,730	313,898	1,551,115	6,674	95,440	36	1,173
Manure salts, including double manure salts	171,757	1,797,057	223,687	2,245,509	168,969	1,846,475	13,753	200,584	1,108	21,273
Phosphates, crude	28,821	231,255	17,121	124,815	15,079	136,526	5,359	50,606	4,612	36,389
Slag, basic, ground or unground	12,596	114,300	13,186	130,455	9,199	105,272	76	1,343	71	759
All other substances used only for manure	127,932	2,660,887	154,729	3,314,460	171,603	3,507,875	72,848	1,535,860	58,993	1,425,636
	999,338	8,893,090	955,436	10,819,253	761,896	9,921,439	160,165	3,970,039	136,445	4,104,647

[a] The statistics in this and following tables were compiled by J. A. Dorsey from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

This table does not include all the imported material that is incorporated in fertilizers manufactured and sold in this country. To the materials indicated should be added the potash salts listed as such in

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the import tables of the Bureau of Foreign and Domestic Commerce—potassium chloride and potassium sulphate—which are largely used in manufactured fertilizers. Moreover, considerable imported sodium nitrate (Chile saltpeter) is used in fertilizers. A large part of the sodium nitrate imported, however, is converted into nitric acid and nitrates for use in making gunpowder and other explosives, matches, and pyrotechnic material, in assaying and analytical operations, and in curing meats. The large importation of sodium nitrate is very significant. Sodium nitrate and potash salts are commodities for which the United States in past years has been entirely dependent on foreign countries. The production of potash salts, an infant industry in the United States, is described in another chapter of Mineral Resources.

Imported materials used in part in the fertilizer industry in the United States, 1914–1916.[a]

	1914		1915		1916	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
Fertilizers	761,896	$9,921,439	160,165	$3,970,039	136,445	$4,104,647
Potassium chloride	165,858	5,745,385	57,741	2,296,606	1,160	348,961
Potassium sulphate	35,914	1,557,224	11,346	664,484	1,512	81,684
Sodium nitrate	545,730	15,204,539	770,628	22,844,746	1,219,609	33,131,364
	1,509,398	32,428,587	999,880	29,775,875	1,358,726	42,666,656

[a] The statistics in this table were compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

There is a small trade in foreign fertilizer materials, which after being imported into this country are shipped elsewhere. The following table compares the export of these foreign fertilizers in 1915 and 1916:

Imported fertilizers shipped, 1915–16.[a]

Kind.	1915		1916	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.
Ammonia sulphate	1,204	$85,255	452	$41 755
Bone dust and bone ash	51	1,602	.....	.....
Guano	.....	30	68	5,864
Kainit	.....	.....	.....	3
Muriate of potash	565	66,599	.....	.....
Sulphate of potash	335	44,159	212	66,238
All other substances used only as fertilizers	.....	113,882	.....	33,103
	2,155	311,587	732	146,963

[a] The statistics in this table were compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

EXPORTS.

A notable feature of the phosphate-rock industry of the last three years has been the decrease of exports. The limit seems to have been reached, for though there was a decrease in exports of 711,000 tons in 1915, the exports in 1916 fell off only 10,000 tons. The total quantity

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of phosphate rock exported in 1916 was 243,678 long tons, valued at $1,156,391. The exports of 1915 and 1916 are compared in the following table:

Phosphate rock exported, 1915–16.[a]

Kind.	1915		1916	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.
Phosphate rock, ground or unground, not acidulated:				
High-grade rock	34,572	$331,524	28,631	$286,948
Land pebble	218,472	1,269,659	214,358	863,078
All other	377	2,668	689	6,365
	253,421	1,603,851	243,678	1,156,391

[a] The statistics in this table were compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

The destination of these exports is shown in the following table:

Phosphate rock, ground or unground, not acidulated, exported, 1915–16.

Country.	High-grade rock.				Land pebble.			
	1915		1916		1915		1916	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
Denmark	7,700	$77,000						
France					4,000	$24,000	22,073	$60,125
Germany	745	7,450						
Italy					7,984	45,984	6,069	16,337
Netherlands					48,374	275,147	27,748	123,046
Portugal	6,423	64,230			3,500	21,000		
Spain	2,908	29,080	3,012	$30,120	63,092	386,892	62,179	273,789
Sweden	16,791	153,714	25,283	253,099	9,955	59,730	31,192	151,543
England					32,501	185,356	23,525	80,543
Scotland					14,876	80,290	9,699	37,050
Ireland					31,500	175,000	25,023	94,568
Canada			336	3,729	2,710	16,260	2,761	10,407
Cuba							4,089	15,620
British Honduras	5	50						
	34,572	331,524	28,631	286,948	218,472	1,269,659	214,358	863,078

Country.	All other.			
	1915		1916	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.
Canada	377	$2,668	676	$6,280
Dutch East Indies			13	85
	377	2,668	689	6,365

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SHOULD THE UNITED STATES CONTINUE TO EXPORT PHOSPHATE?

The following table shows the number of tons of phosphate rock produced in the United States during the last five years, compared with the quantity exported in the same years.

Phosphate rock marketed in and exported from the United States, 1912–1916.

Year.	Proportion of exports to domestic production (per cent).	Marketed production (long tons).	Exports (long tons).
1912	40	2,973,332	1,206,520
1913	44	3,111,221	1,366,508
1914	35	2,734,043	964,114
1915	14	1,835,667	253,421
1916	12	1,982,385	243,678

Prior to 1914 about 40 per cent of the phosphate rock produced in this country was exported. Most of the exported material is high-grade rock from Florida. Some think it very unwise to allow more than 1,000,000 tons of high-grade phosphate to go from this country, as it did before the European war, to enrich the soils of Europe. They believe American deposits of high-grade rock are exhaustible, and when the rock is sent abroad the phosphorus, on which the agricultural prosperity of a country partly depends, is irretrievably lost to us. When we use phosphate rock on our own soils the phosphorus in it can be removed in crops and in large part returned to the soil again in the by-products of the farm—green manure, farm manure, bone meal, and tankage. Not only once, but over and over again, the phosphorus may play its part in producing crops. The economic loss in allowing the phosphate to leave the country is therefore manifold. The phosphate rock that is exported to gain a few million dollars annually would, if applied to our own land, play its part in producing hundreds of millions of dollars in cotton and corn.

Another and broader view, however, may be taken of the situation. The world's annual production of phosphate rock is about 6,000,000 tons. The phosphate reserves in the United States amount to about 6,000,000,000 tons. At the rate of mining during the last few years the high-grade deposits of the Eastern States can not last long. In the Western States, however, there are 5,750,000,000 tons of high-grade material in the areas that have been examined and classified, no account being taken of rock carrying less than 30 per cent tricalcium phosphate. These figures make the situation seem less discouraging. At the present rate of consumption in the entire world, the deposits in the western United States would supply the demand for about 900 years. The use of phosphate for agricultural and other purposes is bound to increase, but it will be a long time before it reaches 10,000,000 tons a year. Even if the world should demand a quantity so large as that, the Western States could supply it for more than 500 years. How long phosphate could be mined and shipped at prices that could be paid abroad is another question.

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GRAPHITE.[1]

By HENRY G. FERGUSON.

INTRODUCTION.

Natural graphite may be either crystalline or amorphous. The term crystalline or flake graphite is commonly understood to mean graphite in crystals large enough to be visible to the naked eye; much of the so-called amorphous graphite shows a crystalline structure under the microscope. Crystalline graphite occurs either in veins, as in the Ceylon deposits, or as flakes disseminated through the country rock, as in most of the crystalline graphite deposits of the United States.

Most deposits of amorphous graphite are the result of the alteration of coal beds by the intrusion of igneous rocks. Amorphous graphite is also made artificially by means of the electric furnace.

USES.

The peculiar physical properties of graphite—infusibility, chemical inertness, high conductivity, extreme softness, and low specific gravity—fit it for many uses, such as the manufacture of crucibles and other refractory products, lubricants, lead pencils, paint, foundry facings, as a preparation to loosen boiler scale, as polish for gunpowder, and for various applications in electrical work.

Graphite is now employed as a lubricant[2] in the manufacture of self-lubricating metals. Molten metal is forced at high pressure into graphite, and the resulting mixture contains about 60 per cent by weight or 25 per cent by volume of the metal. For most purposes graphite is impregnated with babbitt metal. In another process metallic oxides are mixed with graphite and heated to a high temperature. The oxides are reduced to the metallic state by the graphite and the resulting alloy contains an intimate mixture of particles of graphite.[3] The metallized graphite is machined into bushings which in light service are independent of oil lubrication. In the most favorable usage the bushing itself revolves, as in loose pulleys. Graphite metallized with copper is used for many electrical appliances, such as contacts and brushes for motors, generators, and converters.

By far the most important use of graphite is in the manufacture of crucibles, and for this reason graphite is a mineral resource of vital importance in time of war, and American producers of flake graphite have greatly increased their production. The makers of crucibles largely increased their output in 1916, though unable to take full

[1] Part of the material in the following pages is derived from the annual reports on graphite by E. S. Bastin published in the volumes of Mineral Resources of the United States and from Geology of the graphite deposits of the United States, also by E. S. Bastin (U. S. Geol. Survey Bull. —, in preparation).

[2] Yates, R. F., Combining graphite with alloys in the manufacture of self-lubricating metal: Sci. Am., vol. 115, pp. 318–319, Oct. 7, 1916.

[3] U. S. patent No. 1071044, 1913.

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advantage of the increased demand because of the difficulty in obtaining adequate supplies of graphite of crucible grade.

Most makers of crucibles prefer to use Ceylon graphite mixed with 10 to 25 per cent of American flake. The principal reason for the preference for Ceylon graphite is that the flat flake of the domestic graphite has a far greater surface area in proportion to its volume than the more nearly cubical fragments of Ceylon graphite and hence requires a proportionately greater amount of clay as a binder. Some difficulty was experienced in finding a domestic clay to take the place of the Bavarian clay formerly used, but satisfactory clays have now been found. In emergency, however, it should be possible to make satisfactory crucibles entirely from domestic graphite and domestic clay. It appears that in Germany the Bavarian graphite, which is similar to the American flake, is now pressed into lumps and used in place of the Ceylon product.[1] Improved finishing methods may make possible the use of a larger proportion of American flake without further treatment.

For most purposes amorphous graphite, either natural or artificial, may be used with as good effect as the crystalline variety, but for the manufacture of crucibles crystalline graphite is considered essential, as the flakes should be large enough to add to the binding power of the clay.

PRODUCTION AND IMPORTS.

CRYSTALLINE GRAPHITE.

The great increase in the manufacture of brass and crucible steel during the last three years has called for a tremendous increase in the use of crystalline graphite. This has been met for the most part by largely increased imports, particularly from Ceylon, and only in part by the expansion of the domestic graphite industry.

Crystalline graphite imported and produced in the United States, 1911–1916.

Quantity (short tons).

	1911	1912	1913	1914	1915	1916
Imports [a]						
Ceylon	13,119	16,791	16,996	8,755	14,491	26,232
Other countries	2,384	2,819	2,382	2,328	4,504	5,828
	15,503	19,610	19,378	11,083	18,995	32,060
Domestic production	2,395	1,772	2,532	2,610	3,537	5,466
Total available supply	17,898	21,382	21,910	13,693	22,532	37,526
Per cent represented by domestic production	13.4	8.3	11.6	19.1	15.7	14.6

Value.

Imports [a]						
Ceylon	$1,132,678	$1,379,587	$1,674,764	$962,593	$1,746,153	$6,013,362
Other countries	83,124	127,347	160,766	144,599	303,639	920,369
	1,215,802	1,506,934	1,835,530	1,107,192	2,049,792	6,933,731
Domestic production	256,050	187,689	254,328	285,368	417,273	914,748
	1,471,852	1,694,623	2,089,858	1,392,560	2,467,065	7,848,479
Per cent represented by domestic production	17.5	11.1	12.2	20.5	16.9	11.7

[a] From records of the Department of Commerce.

[1] Commerce Repts., March 9, 1917.

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As usual, the greater part of the domestic crystalline graphite was produced by Alabama, New York, and Pennsylvania. The production of these States was all of the variety known in the trade as flake graphite, which occurs as small flakes forming 3 to 10 per cent, by weight, of crystalline schists. In addition, crystalline graphite, resembling in a general way the Ceylon graphite, was produced in Montana, and a small quantity of flake graphite was mined in California and Texas. The quantity of crystalline graphite produced in 1916 exceeded that for any previous year and was an increase of 55 per cent in quantity and of 119 per cent in value over 1915. The number of producers of crystalline graphite was 7 in Alabama, 1 in California, 1 in Montana, 3 in New York, 5 in Pennsylvania, and 1 in Texas.

Crystalline graphite produced in the United States, 1916.

	Quantity.		Value.	
	Pounds.	Percentage of total.	Amount.	Percentage of total.
Alabama	5,226,940	48	$492,407	54
Pennsylvania	1,095,716	10	103,377	11
California, Montana, New York, Texas	4,609,333	42	318,964	35
	10,931,989	100	914,748	100

The principal source of imported graphite is the island of Ceylon, although of late years Madagascar graphite has attained considerable importance. During the greater part of 1916, however, war conditions prevented the export of Madagascar graphite to this country. During 1914 and 1915 the imports from Ceylon were below the normal quantity, owing chiefly to the high freight rates and scarcity of ships; but they increased greatly in 1916. Imports from Canada in 1916 were greatly in excess of those of previous years.

The guaranties required by the British and French governments with respect to importation of Ceylon and Madagascar graphite remain as described in the report on graphite for 1915.[1]

AMORPHOUS GRAPHITE.

Amorphous graphite is suitable for all purposes for which graphite is used except the manufacture of crucibles. As it does not enter to any large degree into the manufacture of munitions, the war has not greatly affected either price or production. Moreover, both artificial graphite and crystalline graphite in particles too small for crucible manufacture are adapted to practically all uses to which natural amorphous graphite can be put. The uses of amorphous graphite vary greatly with the purity of the substance mined. For paint and foundry facings a high degree of purity is not essential; but for lubricants, pencils, and electric purposes high-grade material is necessary. The better grades of amorphous graphite are imported from Mexico and Chosen, and the imports, like those of crystalline graphite, greatly exceed the domestic production.

[1] U. S. Geol. Survey Mineral Resources, 1915, pt. 2, pp. 85, 86, 1917.

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Amorphous graphite imported and produced in the United States, 1911–1916.

Quantity (short tons).

	1911	1912	1913	1914	1915	1916
Imports	5,199	6,031	9,501	10,917	4,080	10,857
Domestic production	1,223	2,063	2,243	1,725	1,181	2,622
Total available supply	6,422	8,094	11,744	12,642	5,261	13,479
Per cent represented by domestic production	19.0	25.6	19.1	13.6	21.9	19.5

Value.

Imports	$279,927	$202,403	$270,217	$290,969	$111,286	$345,752
Domestic production	32,415	32,894	39,428	38,750	12,358	20,723
	312,342	235,297	309,645	329,719	123,644	366,475
Per cent represented by domestic production	10.4	14.0	12.7	11.8	10.0	5.7

On account of the small number of producers, figures showing the domestic production of amorphous graphite by States can not be published without disclosing individual reports. Amorphous graphite was mined in Colorado, Michigan, Nevada, North Carolina, and Rhode Island.

In 1915 internal conditions in Mexico forced the closing of the mines for the greater part of the year, and owing to high freight rates, imports from Chosen also decreased. Imports from both countries, however, increased greatly in 1916.

TOTAL PRODUCTION AND IMPORTS.

Domestic natural graphite sold, 1911–1916.

Year.	Amorphous.		Crystalline.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Pounds.*		*Short tons.*	
1911	1,223	$32,415	4,790,000	$256,050	3,618	$288,465
1912	2,063	32,894	3,543,771	187,689	3,835	220,583
1913	2,243	39,428	5,064,727	254,328	4,775	293,756
1914	1,725	38,750	5,220,539	285,368	4,335	324,118
1915	1,181	12,358	7,074,370	417,273	4,718	429,631
1916	2,622	20,723	10,931,989	914,748	8,088	935,471

Graphite imported for consumption in the United States, 1911–1916.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1911	20,702	$1,495,729	1914	21,990	$1,398,209
1912	25,643	1,709,337	1915	23,075	2,241,163
1913	28,879	2,109,791	1916	42,930	7,279,884

ARTIFICIAL GRAPHITE.

Graphite is manufactured in large quantities at Niagara Falls, N. Y., by the International Acheson Graphite Co., which utilizes electric power generated at the Falls. The bulk graphite produced

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by the company in 1915 was reported as 2,542 short tons and in 1916 as 4,199 short tons. This represents only the graphite that comes into competition with natural graphite and does not include graphitized products that do not compete with natural graphite. This manufactured material, most of which is made either from anthracite or from petroleum coke, is utilized mainly in lubricants and paints and for foundry facings, boiler-scale preventives, and battery fillers.

Besides the graphite products that enter into competition with natural graphite, there are a large number of graphite products for which artificial graphite is particularly adapted. Chief among these is graphite electrodes, the demand for which has greatly increased during the last two years on account of the remarkable growth in certain electrochemical industries. The extent of this growth is indicated by the statement[1] that during 1915 the number of electric steel furnaces in operation in this country increased 78 per cent.

MARKETS AND PRICES.

Ceylon graphite of the better grades is more largely used by crucible makers than domestic flake graphite and, even in normal times, commands a higher price. During the last three years the tremendous increase in crucible manufacture has caused a demand for the Ceylon product greatly in excess of the available supply and the price has constantly increased. The sharp increase of price for all grades of Ceylon graphite in 1916 over that for previous years is in part due to the fact that a much larger proportion of the highest-grade product was imported. In March, 1917, the prices of Ceylon graphite, ex-dock, New York, were approximately as follows: No. 1 lump, 28 to 30 cents a pound; No. 1 chip, 19 to 21 cents; No. 1 dust, 11 to 12 cents.

The prices paid for the highest grade of domestic graphite at the mines in 1916 ranged from 10 to 16 cents a pound. The New York prices varied greatly according to the demand. In the summer of 1916 the price was as high as 18 cents a pound. At the end of the year increased imports from Ceylon reduced the price, and in March, 1917, domestic graphite of good grade could be bought for 12 or 13 cents a pound. The prices paid at the mines for the highest grade product, in cents a pound, have been as follows: 1911 and 1912, 6 to 7; 1913, 6 to 8; 1914, 6½ to 8; 1915, 7 to 10; 1916, 10 to 16.

Average prices of all graphite imported from Ceylon and all crystalline graphite produced in this country, including dust as well as flake, have been as follows:

Average prices of graphite, 1911-1916, in cents per pound.

	Ceylon.	Domestic.		Ceylon.	Domestic.
	Cents.	*Cents.*		*Cents.*	*Cents.*
1911	4.8	5.3	1914	5.5	5.5
1912	4.1	4.2	1915	6.3	5.9
1913	4.9	5.0	1916	12.0	8.4

[1] Iron Age, Jan. 6, 1916, p. 95.

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The sharp increase in the value of the Ceylon graphite imported in 1916 is due largely to the fact that, owing to the high freight rates and scarcity of ships, the higher-grade material formed a larger proportion of the total.

Domestic amorphous graphite brought widely varying prices according to the grade of the product, but in general not greatly in advance of prices before the war. Amorphous graphite from Chosen averaged about $45 a ton on the New York market, a price due largely to the prevailing high freight rates.

The present condition of the graphite market is, with respect to crystalline graphite, the result of a greatly increased demand on account of the war. The high prices have resulted in a large increase in the number of new companies, particularly in Alabama. It is inevitable that after the war prices will be much reduced, but the more efficiently managed companies will probably be able to operate at a profit with prices even lower than those of 1913.

In order to assist producers in marketing their product, the Geological Survey has prepared a list of firms known to be purchasers of domestic graphite. This will be mailed free on request to the Director, United States Geological Survey.

EXPORTS.

The United States imports so much graphite that exports are comparatively unimportant. Since the outbreak of the war, however, there has been a considerable increase in the exports of manufactured graphite articles and a marked falling off in the exports of unmanufactured graphite.

Graphite exported from the United States, 1912–1916.[b]

	Unmanufactured graphite.		Manufactures of graphite.
	Quantity (pounds).	Value.	
1912	4,640,802	$383,458	$177,062
1913	5,383,981	391,906	238,302
1914	3,920,693	277,386	215,878
1915	1,057,764	52,583	536,572
1916	1,595,608	98,118	1,339,259

[a] From reports of the Department of Commerce.

Exports of unmanufactured graphite in 1915 went principally to England, France, Canada, Denmark, and Holland, and in 1916 to England, Canada, France, Spain, and Japan. Graphite manufactures in 1915 were exported principally to England, France, Canada, Switzerland, and Denmark, and in 1916 to Canada, England, France, Portugal, and Italy.

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REVIEW BY STATES AND TERRITORIES.

ALABAMA.

GENERAL FEATURES.

The graphite industry in Alabama advanced notably during 1916, the production being greater by 50 per cent in quantity and 141 per cent in value than that of 1915. There has, moreover, been a great increase in exploitation during the last few months, and therefore it seems desirable to describe the graphite deposits of the State at greater length than has been done in previous reports.

In addition to the 7 companies which produced graphite in 1916, 3 of which were new producers, 2 companies began production between January 1 and April 1, 1917, and 23 others expect to begin operations during the next few months. It is probable that the Alabama output for 1917 will be more than double that for 1916.

The graphite occurs in a graphitic schist which forms lenses in a series of metamorphic rocks traversing parts of Clay, Coosa, and Chilton counties. Quartz is the principal constituent of the graphite-bearing schist, with subordinate amounts of pyrite, mica (biotite), and apatite. These bands of schist rarely exceed 100 feet in thickness and appear to be fairly continuous, though prospecting has not yet proceeded sufficiently to establish their continuity over long distances. The average graphite content of the ore in terms of graphitic carbon is 3 or 4 per cent, though in some places analyses show a carbon content of 5 or 6 per cent. In nearly every deposit the graphite schist is intruded by small stringers of pegmatitic granite. These contain only a little graphite, but appear to have caused a more intense recrystallization of the original carbon in the intruded rock, which has resulted in a coarsening of the flake in the immediate vicinity and possibly in an actual enrichment in the graphite content. The wall rocks are in most places schists that are similar in type to the graphite-bearing schist but contain less graphite and more mica. At a few localities, however, one wall consists of hornblende schist, probably an altered basic intrusive. No graphite is found where the hornblende schist is intruded by granite—an evidence that the carbon from which the graphite is derived is not a product of the granite intrusion. The graphite schists commonly crop out along ridges, and, as a rule, the overburden is very light. The pyrite of the deposits is in most places completely oxidized to the depth of 50 to 60 feet. Besides removing this very objectionable constituent of the ore, weathering has softened the rock and lessened the coherence between the graphite and the other minerals, which facilitates both mining and concentration. The unoxidized schist is avoided as far as possible in mining operations, as it is hard to crush, and the pyrite can be completely eliminated from it only with difficulty. It would, however, be perfectly feasible to treat this "blue rock" should necessity arise.

The following recent articles are of interest in regard to the graphite deposits of Alabama:

Prouty, W. F., Flake graphite in Alabama; its location, its history, and its value to the State: Birmingham Age-Herald, January 28, 1917.

——— Extent and development of flake graphite resources of Alabama: Manufacturers' Rec., April 19, 1917, pp. 66–67.

Pratt, J. H., Alabama graphite deposits: Manufacturers' Rec., March 22, 1917, p. 58.

Herr, Irving, Clay County graphite district of Alabama: Eng. and Min. Jour., vol. 103, pp. 693–697, April 21, 1917.

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MINING AND CONCENTRATION.

Mining is done in open cuts, and in common practice a 30-foot face is broken down with a single charge of dynamite and the material loaded into cars. The large blocks are broken by hand or by small charges of powder. In loading a certain proportion of low-grade material is discarded. The deposits with steep dips are, of course, at an advantage over others in the costs of mining.

Milling methods are much the same in most of the mills and may be described briefly. Large bins have been installed in most of the newer mills to allow steady runs even in wet weather, as it is of great advantage to have the ore as dry as possible. The ore passes to a jaw crusher, where it is broken to about 1-inch size and next to a rotary cylindrical drier. In some mills rolls are used before drying. The dry ore is next crushed in rolls and screened, the oversize going back to the rolls and the fines passing to the water-flotation concentrator. In some mills the crushed ore first passes through an air separator in which a suction fan removes the graphite and dust and leaves the coarser sand behind. This process is open to the objection that a certain quantity of coarse flake is left behind with the sand and some fine graphitic dust is inevitably lost. Where a middling product is made, it is returned to the rolls. In some of the newer mills the graphitic sands pass from the drier into cooling bins, where they remain 24 hours, the bins being drawn on alternate days. The reason for this is that water flotation has been found to act more effectively on cool material.

The principal concentration process is water flotation. The flotation separator is a rectangular trough 5 to 9 feet long, 6 to 10 inches wide, and 12 to 18 inches deep. This trough is filled with water, which is supplied in a thin curtain from the top along the entire length of one side and overflows into a launder on the other side. The amount of water is regulated so that the flow across the trough shall be as smooth and free from ripples as possible. The graphitic sand is fed in a thin stream onto the moving water surface. In a few mills the sand is fed over a revolving shaft which distributes the feed more evenly. Most of the sand sinks, and the graphite flakes, together with a little mica and fine grit, float off on the moving water. A recent modification of the flotation separator is circular in form and about 6 feet in diameter, and in it the sand is fed at the apex of a stationary or revolving cone.

The launders carry the concentrates to shaking screens, on which they are freed from surplus water. Fine sprays falling on these screens wash out a part of the fine grit. In one mill a hexagonal reel is used instead of the shaking screen. The concentrates are next dried on a concrete drying floor heated by steam or in double-chambered rotary cylindrical driers. In some mills the concentrates then pass through another air separator. This removes whatever coarse grit has been floated with the graphite.

The finishing process consists of grinding in burrstone mills and screening in bolting reels or inclined shaking screens of the kind used in flour mills. The purpose of the burr mill is to break the grains of quartz so that they will pass through the finest screen with the dust while the No. 1 and No. 2 flake remains as oversize from the different screens. In a few mills electrostatic separation has been tried in

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place of burr mills for the final finishing, but in the Clay County mills it has not proved satisfactory.

Three mills use processes different from that outlined above. The new mill of the Alabama Graphite Co. uses a wet process for the preliminary concentration. The material is crushed in jaw crushers and is then fed with water into the muller and from that to a log washer, in which the sands are screened toward the discharge at the upper end while the graphite flakes float off at the lower end. The dewatering and finishing process is the same as that outlined above. The Ceylon Co. uses an oil-flotation process and the Flaketown Graphite Co. uses a dry process throughout.

The usual Alabama system as outlined above is open to the following objections:

1. The recovery is low; in most mills the total of the finished product amounts to about 2 per cent of the ore handled. As none of the final product is pure graphite, this probably means a total saving of not over 60 per cent of original graphite content.

2. The quantity of dust is too great in proportion to the quantity of No. 1 flake produced. The proportion of different products varies from 40 to 50 per cent of No. 1 flake, 20 to 15 per cent of No. 2 flake, and 40 to 35 per cent of dust. Grinding dry in the muller or Chile mill and the final grinding in the burr mills probably breaks the flake badly.

3. Under the present system the ore must be dried before the graphite can be separated by water flotation and the concentrates must be dried again before finishing. A wet concentration process would eliminate the preliminary drying.

4. There is no uniform standard for No. 1 flake. A few producers guarantee a 90 per cent carbon content but the majority produce No. 1 flake carrying about 85 per cent.

5. The dust-filled mills can not fail to be injurious to the health of the workers.

MINES.

The following notes in regard to mining operations are largely the result of the writer's observations during a brief trip to Clay and Coosa counties in April, 1917. E. S. Bastin made a more extended trip to the region during May and June, 1916, and his notes have been consulted in the preparation of the following descriptions. The mines are described in alphabetic order for each county.

CLAY COUNTY.

The graphite area of Clay County, as shown on the maps accompanying articles by Prouty,[1] extend in an irregular belt from the extreme northeast corner of the county southwestward to a line drawn from Coleta to Millerville, a total length of about 27 miles. The maximum width does not exceed 4 miles. At present development is confined to the portion of this belt in the vicinity of Ashland and Lineville, and the producing mines are in the southern part of T. 19 S., R. 8 E., the northwestern part of T. 20 S., R. 8 E., the central and southwestern part of T. 20 S., R. 7 E., and the south-

[1] Prouty, W. F., Flake graphite in Alabama; its location, its history, and its value to the State: Birmingham Age-Herald, Jan. 28, 1917; Extent and development of flake graphite resources of Alabama: Manufacturers' Rec., Apr. 19, 1917, pp. 66-67.

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eastern part of T. 20 S., R. 6 E. Ashland is the principal shipping point.

The Acme Graphite Co. (office, Birmingham, Ala.) is building a large mill in the SE. ¼ sec. 16, T. 20 S., R. 7 E., about 5 miles west of Ashland. The strike of graphite schist is N. 40° E., the dip about vertical. The graphitic band shows a width of about 100 feet. On the northwest is hornblende schist and to the southeast quartz-mica schist containing a little graphite.

The Alabama Graphite Co. (office, Ashland, Ala.) has been a large producer since 1912. The old mill, in the NW. ¼ sec. 21, T. 20 S., R. 7 E., is of the usual type in the district and has a capacity of about 125 tons per 10-hour day. An electrostatic separator was formerly used in the finishing mill but has now been given up. There are several bands of graphitic schist near the mill. Work is at present confined to one of these which has a maximum width of about 60 feet. A new mill has been erected about 1½ miles to the west of the old one. A wet concentration process is used here, and the concentrates are carried to the old mill for finishing. The graphitic schist near the new mill has been partly uncovered, but mining had not begun at the time of visit.

The American Graphite Co. (office, Ashland, Ala.) has a mill nearly completed in the SW. ¼ sec. 7, T. 20 S., R. 8 E., about 1½ miles north-northwest of Ashland. The proposed milling process departs from the usual practice, in that a series of rolls is substituted for the muller, with the object of breaking the flake as little as possible. Air separation is to be introduced between the rolls and the water flotation. The deposit is wide and shows coarsening of the flake near the small granite stringers.

The Axton Noe Graphite Co. (office, Ashland, Ala.) has a large mill nearly completed in the SE. ¼ sec. 17, T. 20 S., R. 7 E. The water-flotation separators being installed are of the circular type known as the Comer washer. Inclined screens will be used instead of bolting reels in the finishing mill.

The property of the Black Diamond Graphite Co. (office, Ashland, Ala.) is in the SE. ¼ sec. 24, T. 20 S., R. 6 E., about 7 miles west of Ashland.

The Central Graphite Co. (office, Ashland, Ala.) has recently been organized to work property in sec. 12, T. 20 S., R. 7 E., about 3 miles northwest of Ashland.

The mine and mill of the Clay County Graphite Co. are in the SW. ¼ sec. 8, T. 20 S., R. 8 E., about 2 miles north of Ashland, on the Ashland branch of the Atlanta, Birmingham & Atlantic Railway. The company has been a producer since March, 1916. The graphitic schist strikes northeast and dips about 25° SE. The mill is of the usual type, except that the muller is replaced by roughing and finishing rolls and the sands pass through a suction concentrator before water flotation. The finishing process is more elaborate than usual. The first step consists of air-blast concentration, followed by grinding in flour rolls and burr mills, with screening through a series of bolting reels. Besides the usual No. 1 and No. 2 flake and dust, a fourth product known as special dust and containing from 44 to 55 per cent carbon is also made.

The Crucible Flake Graphite Co. (office, Ashland, Ala.), formerly the Standard Graphite Co., has been a producer since November,

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1916. Two large veins are now worked and others have been prospected. This is the only mine at which the unweathered rock is mined as well as the oxidized. It is said that this material is handled with little extra expense and gives a satisfactory concentrate. The flow sheet of the mill differs only slightly from that outlined on page 50. From the second drier the concentrates pass to blast fans, the sands from which are returned to the fine rolls, and pass again through the water-flotation separators. The mine is in sec. 30, T. 20 S., R. 6 E.

The Eagle Graphite Co. (office, Ashland, Ala.) has a mill nearly completed in the NE. ¼ sec. 30, T. 20 S., R. 7 E., about 7 miles west of Ashland. The graphite-bearing schist here strikes N. 50° W., dips 50° SE., and contains a considerable amount of large flake. On the footwall, now being cut to develop the deposit, is hornblende schist with garnetiferous streaks. The mill is expected to have a daily capacity of 150 tons. Roughing and finishing rolls will be used instead of the muller, and the sands will pass through an air concentrator before reaching the water-flotation machines.

The Empire Graphite Co. (office, Ashland, Ala.) owns property in secs. 31 and 32, T. 20 S., R. 7 E., about 6½ miles west-southwest of Ashland.

The property of the Great Southern Graphite Co. (office, Birmingham, Ala.) lies in sec. 14, T. 19 S., R. 8 E., about 8 miles north-northeast of Ashland, and is the easternmost of the Clay County mines. The plans for the mill have been completed and work is proceeding on the ground. It is expected that the mill will be in operation in June or July, 1917.

The mill of the Greismer Co. (office, Ashland, Ala.) is in the NE. ¼ sec. 21, T. 20 S., R. 7 E., about 4 miles west of Ashland; and the company owns a large area in secs. 15, 16, 21, and 22 of the same township. There are said to be six workable bands of graphitic schist from 50 to 100 feet wide on the property. Operations will at first be confined to a band of schist that crops out on the top of a high ridge about 1,000 feet south of the mill, and the ore will be brought to the mill by gravity tram. The strike of the schist is here about N. 75° E. and the dip is 65° SE. The mill is one of the largest in the district and is expected to have a capacity of 400 tons of ore in 24 hours. The crushing is to be done by a series of rolls and air separators will be employed before and after water flotation. In the finishing mill inclined screens will take the place of bolting reels.

The Jennings Graphite Co. (office, Ashland, Ala.) has been a producer since December, 1914. The old mill is in the NE. ¼ sec. 8, T. 20 S., R. 8 E., 2¼ miles north-northeast of Ashland. A second mill, a short distance to the east, in the NW. ¼ sec. 9, is nearly completed. The band of graphitic schist worked at the old mill is from 50 to 100 feet in width, has a strike of about N. 60° E., and dips 45° SE. A band of micaceous material in the center is avoided in mining. At the new mill a rather narrower but apparently higher-grade body will be mined. The milling process is similar to that of neighboring mills except that electrostatic separation is introduced as a preliminary step in the finishing process. The new mill will be equipped only for concentration, and the concentrates will be finished in the finishing mill of the old plant.

The King Graphite Co. (office, Lineville, Ala.) has cleared ground for a 200-ton mill in the SE. ¼ sec. 6, T. 20 S., R. 8 E., 2½ miles north

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of Ashland. It is expected that the company will begin operations by September, 1917. A 50-foot band of graphitic schist has been exposed by trenches. The schist strikes northeast and dips 45° SE.

The mill of the Lineville Graphite Co. (office, Lineville, Ala.), in the SW. ¼ sec. 22, T. 19 S., R. 8 E., 6 miles north-northeast of Ashland, has been in operation since the middle of March, 1917. A series of rolls take the place of the muller used in the older mills and the water-flotation machines are of the circular type. The waste products from the finishing process are returned to the water-flotation machines.

The May Brothers Graphite Co. (office, Ashland, Ala.) has a mill under construction in the SW. ¼ sec. 16, T. 20 S., R. 7 E. It is expected that operations will begin by September, 1917.

The Monitor Graphite Co. (office, Ashland, Ala.) is beginning the construction of a large mill in the NW. ¼ sec. 8, T. 20 S., R. 8 E., 2½ miles north of Ashland. The graphitic schist, which has been exposed on the hill above the mill, strikes N. 70° E., and dips 50° SE. The ore grades off into lean material on each side, but it is expected to give a workable thickness of about 100 feet.

The property of the National Graphite Co. (office, Ashland, Ala.) lies in the NW. ¼ sec. 13 and the SW. ¼ sec. 12, T. 20 S., R. 7 E., about 2 miles northwest of Ashland. The mill is nearly completed.

The mill of the Peerless Flake Graphite Co. (office Lineville, Ala.) is nearly ready for operation. The property of the company lies in the NE. ¼ sec. 33 and the NW. ¼ sec. 34, T. 19 S. R. 7 E., nearly 5 miles north-northeast of Ashland.

The Quenelda Graphite Co. (office, Ashland, Ala.) owns large tracts of land in the western part of the district and has been a producer since 1913. The mill is in the SW. ¼ sec. 17, T. 20 S., R. 8 E., about 6 miles west of Ashland. The mine is about 2,000 feet southeast of the mill and the ore is hauled to the mill by steam locomotives. Two bands of schist striking about N. 60° E. and having a vertical dip are being mined. They average about 100 feet and 40 feet in width. In the center of the larger band, a lenticular horse of granite about 20 feet wide and 100 feet long has been left standing.

The mill follows the usual practice, except that a double cooling bin takes the crushed ore from the drier and is drawn on alternate days. In addition to 24 flotation machines of the usual type one circular machine is being tried. Air separation is not used except just prior to finishing, where a small electric fan takes out part of the sand.

The Southern Graphite Co. (office, Ashland, Ala.) began producing in 1916. The mill and mine are in the SW. ¼ sec. 13, T. 20 S., R. 7 E., 2 miles west-northwest of Ashland. The band of graphitic schist now being mined has a workable width of about 60 feet. The strike is northeast and the dip about 40° SE. A smaller band on the hanging-wall side was mined to some extent in the course of the preliminary operations. The average graphite content of the ore is said to be about 3 per cent, though several analyses showed material from 4 to 4.1 per cent. Two other schist bands, as yet unworked, have been prospected. The milling system is the same as elsewhere in the district and consists of jaw crusher, muller, rotary drier, water flotation, cylindrical drier, air separator, and finishing burr-mills and bolting reels.

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The Southern Star Graphite Co. (office, Ashland, Ala.) is constructing a mill in the SE. ¼ sec. 16, T. 20 S., R. 7 E., 4½ miles west of Ashland. It is expected that operations will begin by June, 1917. The mill will be of the usual type and consist of jaw crusher, muller, rotary drier, cooling bin, water flotation, drying floor, air separator, and finishing mill. The graphite schist is here about 90 feet in width.

Besides the mines mentioned above there are several other companies planning to begin operations in the near future. Among these are the C. B. Allen Graphite Co., the Birmingham Graphite Co., the Black Diamond Graphite Co. (property in sec. 24, T. 20 S., R. 6 E. and sec. 19, T. 20 S., R. 7 E.), the Consolidated Graphite Co., the Dixie Graphite Development & Mining Co., the Graphite Development & Mining Co., the Graphite Development Co., the Hood Graves Co., the Norway Graphite Co. (property in sec. 22, T. 20 S., R. 6 E.), and the Superior Flake Graphite Co. (property in secs. 15, 21, and 22, T. 19 S., R. 8 E.).

COOSA COUNTY.

The graphite-bearing belt of Coosa County extends from Goodwater southwestward to Coosa River. It is only in the Goodwater region, however, that active work is in progress. No production was made from this district during 1916, but in April, 1917, one company had a mill in full operation, another was building its mill, and three more contemplated beginning construction within a short time.

The Ceylon Co. (office, Birmingham, Ala.) has erected a large mill in the NE. ¼ sec. 16, T. 24 W., R. 19 E. A special process is used, the details of which are not made public. The graphite-bearing schist is said to average about 150 feet in width and has been prospected for 1,000 feet along the strike. The strike is about N. 35° E. and the dip is 55°–60° SE. The outcrop follows the crest of a prominent ridge, on the north side of which the mill has been built. An open cut is being carried across the deposit at the level of the ore bin, and it is planned to work back from this toward the mill, thus gaining the advantage of working against the dip. The ore grades off on the walls into leaner quartz schist containing small bands of graphitic schist. The graphite is shipped from Hollins, a station on the Central of Georgia Railway about 7 miles west of Goodwater.

The Goodwater Graphite Co. (office, Goodwater, Ala.) is erecting a mill about 1½ miles northwest of Goodwater and expects to be ready for operations by June 1, 1917. The ore will be crushed by a series of jaw crushers and rolls and circular water-flotation machines will be used for concentration. The graphite-bearing schist, which has a width of about 40 feet, strikes N. 70° E. and dips about 25° SE.

The Graphite Co. of America (office, Birmingham, Ala.) is planning to develop a large area of about 2 miles northwest of Goodwater, between the property of the Goodwater Graphite Co. and Hatchet Creek. Graphite-bearing schist has been exposed in several pits and trenches. The strike is about N. 70° E. and the dip averages 45° SE. It is planned to use a dry process in the mill.

The Royal Graphite Co. and the United Graphite Co. are also prospecting lands in the vicinity of Goodwater.

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CHILTON COUNTY.

The only plant in operation in Chilton County is the Flaketown Graphite Co., about 3½ miles northeast of Mountain Creek station on the Louisville & Nashville Railroad. The property was visited by Mr. Bastin in May, 1916, and will be described at length in the forthcoming bulletin on graphite deposits of the United States. A special process is employed at the mill, the details of which are not made public.

FUTURE OF THE ALABAMA GRAPHITE INDUSTRY.

The large number of new companies beginning operations at the present time naturally makes it of importance to consider the probable effect of the future increased production upon the market. If all the mills in the Alabama field are able to operate at anything like their expected capacity, the result will be an annual production of flake graphite of approximately 30,000,000 pounds, about 15 times the production of Alabama in 1913 and nearly equal to the entire importation from Ceylon for that year. As long as the war continues a largely increased production can probably be absorbed by crucible makers and other users of crystalline graphite, but if the graphite from Ceylon and Madagascar continues to enter the market freely, the price of domestic graphite will necessarily be reduced with the increase in production. With a return of peace, however, operators will face an unfavorable condition caused by a decreased market and large increase in production. On the other hand, mining conditions in Alabama are very favorable, the mining costs are low, and new developments in concentration and finishing will probably result in a larger percentage of good flake in the finished product and a higher saving of graphite of all grades. Costs of mining and milling at an efficiently managed plant should not exceed $50 a ton of concentrates produced, or about 2½ cents a pound for the finished product, and even with prices as low as 5 cents a pound for No. 1 flake, 3 cents for No. 2, and 1½ cents for dust, there should still be a possibility of profit. A recent article by Prouty [1] contains an interesting discussion of costs of production of graphite in Alabama. It is of course idle to speculate on the possible duration of present conditions, and the situation may be summed up by saying that as long as the present demand for crucibles in the manufacture of munitions continues, the plants in operation should all be able to make profits, and even with the expected drop in prices after the war the most favorably situated and efficiently managed plants should continue to be profitable.

ALASKA.

The Alaska Graphite Co. and the Uncle Sam Alaska Mining Syndicate continued development work in the Port Clarence mining district, Seward Peninsula, Alaska, but no graphite was marketed.

ARKANSAS.

Deposits of graphite are said to exist in Howard County and in the western part of Pulaski County, Ark. Nothing is known in regard to the nature of these deposits.

[1] Prouty, W. F., Extent and development of flake graphite resources of Alabama: Manufacturers' Rec., Apr. 19, 1917, pp. 66–67.

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CALIFORNIA.

The graphite deposits of California were described in detail in the Geological Survey reports on graphite for 1914 and 1915.[1] One company, the California Graphite Co., of Los Angeles, reported production in 1916.

COLORADO.

Amorphous graphite of good grade was discovered in 1916 by Woodruff & Woodruff, of Greeley, Colo., near Pitkin, in Gunnison County. The deposit was developed during 1916 and yielded a small production, which will be increased in 1917.

MICHIGAN.

The Detroit Graphite Co. resumed operations during 1916 and obtained a large quantity of amorphous graphite from its mine near L'Anse, Baraga County, Mich.

MONTANA.

Graphite mining was continued during 1916 at the mine of the Crystal Graphite Co., near Dillon, Mont., with gratifying results. Considerable shipments were made to the eastern markets. This deposit is of particular interest, as the graphite closely resembles the Ceylon product, both in physical character and in mode of occurrence.

NEVADA.

The Black Lead Mining Co., of Carson, Nev., continued the production of amorphous graphite. The deposit was described in detail in the Geological Survey report on graphite in 1915.[2] The product is shipped to the mill of the company at Oakland, Cal., and prepared for use as a paint pigment.

J. A. Kelly, of Rawhide, Nev., reports the discovery of a graphite deposit in Mineral County, 25 miles southwest of Rawhide.

NEW YORK.

The mine of the Joseph Dixon Crucible Co., Warren County, N. Y., was operated continuously in 1916 and the production was largely increased. The Graphite Products Corporation, with mines in the towns of Wilton and Greenfield, in Saratoga County, also increased its production. The Popes Mill Graphite Co. reported a small production from its mine at Popes Mill, St. Lawrence County. The Hooper Bros., of Whitehall, have been developing a deposit near Dresden, in Washington County, but did not market any graphite during the year.

The graphite deposits of New York have been described in a recent article.[3]

NORTH CAROLINA.

Except for a small output of amorphous graphite mined in Catawba County by the Aetna Graphite Co., of Columbus, Ohio, no graphite was produced in North Carolina in 1916. H. M. Ashe & Co., of Atlanta, Ga., have prospected graphite deposits in Macon County.

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[1] U. S. Geol. Survey Mineral Resources, 1914 and 1915, pt. 2.
[2] U. S. Geol. Survey Mineral Resources, 1915, pt. 2, p. 90, 1916.
[3] Jones, R. W., Graphite industry in New York: Eng. and Min. Jour., vol. 102, pp. 773-775, Oct. 28, 1916.

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PENNSYLVANIA.

Chester County has for many years been the center of the graphite industry of Pennsylvania and within the last 10 years has been the sole productive district in the State. The rocks mined for graphite are graphitic quartz-mica schists and minor amounts of graphitic limestone.

The production of flake graphite for the State in 1916 showed a gratifying increase over that for 1915 and is to be credited to the following companies: Graphite Products Co., Uwchland, with mines at Byers, Chester County; T. D. Just Co., Philadelphia, with mines at Chester Springs, Chester County; Rock Graphite Mining & Manufacturing Co., Philadelphia, with mines at Chester Springs, Chester County; Tonkin Graphite Co., Byers, with mines at Byers, Chester County; Standard Carbon Co., Philadelphia, with mines at Pikeland, Chester County.

RHODE ISLAND.

The mine of Frank D. Fenner, of Arlington, at Fenners Ledge, in the outskirts of Providence, R. I., continued production in 1916. The graphite is of the amorphous type and is used for foundry facings, paint pigment, and boiler compound. An occurrence of amorphous graphite on the west shore of Conanicut Island, near its north end, has been reported to the Geological Survey. Samples forwarded to the Survey show a type of material that should be excellent for the same purposes as the product from Fenners Ledge.

TEXAS.

The first production of graphite in Texas was made in 1916. The graphite is of the crystalline or flake variety and occurs in the pre-Cambrian schists in Llano and Burnet counties.

The deposits were visited by E. S. Bastin in June, 1916, and described by him as follows:[1]

> The graphite deposit near Burnet, Tex., is being exploited by a group of Los Angeles men, who are associated under the name of the Texas Graphite Co. * * * The mine is 8 miles (12 miles by road) west-northwest of Burnet, in Burnet County, on the west side of Clear Creek, a tributary of Colorado River. The shipping point will be Burnet, on the Houston & Texas Central Railroad.
>
> The graphite here, like that in the Alabama deposits, forms small flakes in a crystalline schist into which more or less granite pegmatite has been injected. The graphite schist forms a band 100 to 200 feet wide that is traceable almost continuously for about 4,000 feet. Careful sampling of the western 1,400 feet of the deposit by an engineer employed by the company showed that the rock contains 10.3 per cent of graphite. The samples assayed weighed in all 11,000 pounds, and in determining the percentage of graphite the higher assays were excluded. Within the commoner type of light-gray graphite schist there are a number of large lens-shaped bodies of dark-gray schist in which graphite is notably more abundant and forms larger flakes. Though the flakes of graphite are on the average smaller than those in the Alabama deposits, a preliminary examination indicates that the deposit will yield a fair proportion of flakes that are large enough to be used for making crucibles. * * * The product will be hauled to Burnet and shipped by rail to Galveston and thence by water to New York.

No graphite was marketed during 1916 by the Texas Graphite Co. W. McCarty Moore, of Llano, recently purchased the mill of the Llano Gold & Rare Metal Mining Co. and after adapting it to the concen-

[1] Graphite mining active in the South: U. S. Geol. Survey Press Bull. 280, July, 1916.

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tration of graphite began production in December, 1916. The mine is 5 miles northeast of Llano.

The Wakefield Iron & Coal Land Improvement Co., of Minneapolis, Minn., is also developing a graphite deposit in the same region.

WASHINGTON.

A graphite deposit in Chelan County, Wash., was developed by John Maloney, of Skykomish, but owing to lack of transportation at the mines no graphite was marketed. The graphite, according to the samples submitted, is crystalline, but most of the flakes are considerably less than 0.5 millimeter in diameter.

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SLATE.

By G. F. Loughlin.[1]

PRODUCTION.

GENERAL STATISTICS.

The condition of the slate industry as a whole remained in 1916 essentially the same as in 1915, the poorest since 1901. The total value of slate sold in 1916 amounted to $5,338,837 and exceeded that sold in 1915 by $379,922, or 7.7 per cent. This apparent increase was due largely to the receiving of data that had not previously been collected. If these data are excluded, the increase is so small as to be disappointing in view of the great activity in building that began late in 1915 and continued through 1916.

The accompanying table, however, shows that there was an increase of more than 26 per cent in quantity and of 44 per cent in value of mill stock, the value representing over one-fifth of the total value of slate. The quantity of mill stock sold in 1916 amounted to 5,782,842 square feet and exceeded the quantity sold in seven of the nine preceding years. The value of mill stock in 1916 was $1,177,260 and exceeded that of each of the nine preceding years except 1913, which was greater by more than $56,000. The price of mill stock in 1916, 20 cents a square foot, was greater than in any other year.

Slate sold in the United States, 1907–1916.

Year.	Roofing slate.			Mill stock.			Other uses (value).	Total value.
	Number of squares (100 sq. ft.).	Value.	Average price per square.	Quantity (square feet).	Value.	Average price per square foot.		
1907	1,277,554	$4,817,769	$3.77	5,979,624	$943,409	$0.157	$258,042	$6,019,220
1908	1,333,171	5,186,167	3.89	4,793,812	793,304	.165	337,346	6,316,817
1909	1,133,713	4,394,597	3.87	5,112,894	876,089	.171	170,732	5,441,418
1910	1,260,621	4,844,664	3.84	5,181,498	999,098	.192	392,997	6,236,759
1911	1,124,677	4,348,571	3.87	5,744,577	1,027,605	.178	351,843	5,728,019
1912	1,197,288	4,636,185	3.87	5,765,273	1,013,220	.176	393,913	6,043,318
1913	1,113,944	4,461,062	4.00	6,312,011	1,233,838	.195	480,576	6,175,476
1914	1,019,553	4,160,832	4.08	5,361,925	977,930	.182	568,025	5,706,787
1915	967,880	3,746,334	3.87	4,576,112	819,672	.179	[a] 392,909	4,958,915
1916	835,873	3,408,934	4.08	5,782,842	1,177,260	.20	[a] 752,643	5,338,837
Percentage of increase or decrease	−13.6	−9.0	.....	+26.4	+43.6	.....	+91.5	+7.7

[a] Includes, in 1915, 4,843,432 school slates, valued at $38,167, and 3,152,771 square feet of blackboard material, valued at $349,959; in 1916, 4,990,007 school slates, valued at $52,561, and 3,182,159 square feet of blackboard material, valued at $403,502.

[1] All tables in this report have been compiled by Miss A. T. Coons from figures reported by the producers to the United States Geological Survey.

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This encouraging increase in mill stock was offset by decrease in sales of roofing slate, whose value represents a little over three-fifths of the total. The quantity of roofing slate sold in 1916 was the lowest since 1896 and amounted to 835,873 squares—a decrease of 132,007 squares, or nearly 14 per cent, compared with 1915. The value of roofing slate sold in 1916 was the lowest since 1898 and amounted to $3,408,934—a decrease of $337,400, or 9 per cent, compared with 1915. The average price per square, however, rose from $3.87 in 1915 to $4.08, the highest price on record, which was equaled in 1914.

The decrease in sales of roofing slate, in spite of the great increase in building, may be attributed to the fact that many of the buildings erected were factories and other flat-roofed buildings, necessitated by enlargement, owing to the war in Europe, of industries that have generally been supplied with roofing material of other kinds. Artificial materials were doubtless used also on many newly erected dwelling houses, as in previous years. The increased cost of metals, the demand for them in other uses, and the increased cost of asbestos and other materials used in artificial roofing may give roofing slate an opportunity to regain some of this lost ground. Slate, either in ordinary shingles, as inlaid slate, or as filler for asphaltic roofing material, is available for use on roofs of all kinds.

The value of slate sold for other uses amounted to $752,643 in 1916. This value, nearly double that in 1915, represents both a very substantial increase by producers reporting in both years and a considerable production from sources that reported for the first time. A considerable part of this value was represented by slate for blackboards and school slates, the output of which increased in both quantity and value in 1916. Return to the use of school slates with due sanitary precautions, in view of the increasing cost of paper, has recently been urged in Great Britain in editorials of the Slate Trade Gazette. This suggestion may be worthy of consideration in many American cities also. Nearly two-thirds of the total value of school slates sold in 1916 was represented by exports, as is shown in the table on page 71. The remainder of slate sold for other purposes included small quantities sold for structural purposes, for "inlaid slate," and for ground and pulverized slate. A considerable quantity of ground slate is used in the making of an artificial roofing. A green rock, colored by the mineral epidote, has been quarried in Virginia and Pennsylvania, and ground for use as coloring matter in artificial roofing material.

The producing States in 1915 all continued active in 1916, as shown in the next table, and a small production was also reported from California. Of these, the two leading States, Pennsylvania and Vermont, showed respective increases of about 3 and 30.2 per cent in total value of slate sold. Maine, New Jersey, and Utah, whose total sales are included in those of "Other States" because less than three companies in each State sold both roofing slate and mill stock, also showed increase. Maryland, Virginia, and New York, all of which showed increase in total value in 1915, showed marked decrease in 1916—the first two, 21, and the last, 83 per cent. Almost the entire production of these three States was roofing slate.

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Slate sold in the United States, 1912–1916, by States.

State.	1912	1913	1914	1915	1916	Percentage of increase or decrease.
Arkansas	(a)					
California					(a)	
Georgia		(a)				
Maine	$282,678	$323,998	$277,419	(a)	(a)	
Maryland	92,184	83,993	77,391	$91,277	$71,737	−21.4
New Jersey	(a)	(a)	(a)	(a)	(a)	
New York	135,207	144,882	112,776	127,603	21,345	−83.3
Pennsylvania	3,474,247	3,733,581	3,609,959	3,044,269	3,124,743	+ 2.6
Utah			(a)	(a)	(a)	
Vermont	1,849,975	1,697,820	1,414,247	1,234,891	1,607,901	+30.2
Virginia	195,392	175,830	204,139	210,612	165,483	−21.4
Other States	b 13,635	c 15,372	d 10,856	e 250,263	f 347,628	
	6,043,318	6,175,476	5,706,787	4,958,915	5,338,837	+ 7.7

a Included in "Other States."
b Includes Arkansas and New Jersey.
c Includes Georgia and New Jersey.
d Includes New Jersey and Utah.
e Includes Maine, New Jersey, and Utah.
f Includes California, Maine, New Jersey, and Utah.

The marketed production and the conditions in the different States during 1915 and 1916 are shown in detail in the following table:

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State.	Number of operators.	Roofing slate.			Mill stock.[a]						Other.	Total value.
		Number of squares (100 square feet).	Value.	Average price per square.	Manufactured.		Rough.		Total.			
					Quantity (square feet).	Value.	Quantity (square feet).	Value.	Quantity (square feet).	Value.		
1915.												
Maine	3	14,257	$83,919	$5.89								(b)
Maryland	3	14,912	89,589	6.01							$1,688	$91,277
New Jersey	3											(b)
New York	10	29,226	127,603	4.36								127,603
Pennsylvania	81	574,223	2,142,173	3.71	2,987,872	$479,254	567,526	$32,618	3,555,398	$511,872	[c] 390,224	3,044,269
Utah	1											(b)
Vermont	41	284,362	1,085,887	3.82	537,734	130,221	125,069	18,186	652,803	148,407	597	1,234,891
Virginia	8	49,308	210,612	4.27								210,612
Other States[d]		1,592	6,551	4.12	367,911	159,393			367,911	159,393	400	250,263
	150	967,880	3,746,334	3.87	3,883,517	768,868	692,595	50,804	4,576,112	819,672	392,989	4,958,915
1916.												
California	1			8.96								(b)
Maine	3	10,263	75,563	7.36								(b)
Maryland	3	11,777	70,404	5.98							1,333	71,737
New Jersey	1			3.50								(b)
New York	9	2,727	21,345	7.83								21,345
Pennsylvania	81	531,342	2,056,324	3.87	3,397,404	576,030	633,377	43,457	4,030,781	619,487	[e] 448,932	3,124,743
Utah	1											(b)
Vermont	39	242,723	1,015,661	4.18	968,152	263,765	180,567	27,476	1,148,719	291,241	300,999	1,607,901
Virginia	8	36,007	165,483	4.60								165,483
Other States[d]		1,034	4,154		602,342	266,532			603,342	266,532	1,379	347,628
	146	835,873	3,408,934	4.08	4,968,898	1,106,327	813,944	70,933	5,782,842	1,177,260	752,643	5,338,837

[a] Mill stock is classed as rough or manufactured according to the condition in which it is sold by the quarrymen; whether as rough blocks to slate mills or in finished or partly finished condition from the producers' mills at the quarries.

[b] Included in other States.

[c] Composed of 4,843,432 school slates, valued at $38,167; 3,152,771 square feet of blackboard material, valued at $349,959; and slate used for other purposes, valued at $2,098.

[d] Includes, in 1915, Maine, New Jersey, and Utah; in 1916, California, Maine, New Jersey, and Utah.

[e] Composed of 4,990,007 school slates, valued at $42,561; 3,182,159 square feet of blackboard material, valued at $403,502; and slates used for structural and other purposes, valued at $2,869.

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The number of active producers, which has been steadily decreasing in recent years, continued to decrease in 1916, 146 companies reporting sales for that year, compared with 150 in 1915. Only in California did the number of active producers increase. In Maine, Maryland, Virginia, and Pennsylvania it remained the same as in 1915. All the States producing roofing slate in both years showed decrease in both quantity and value, although all except Maryland showed increase in average price per square. All those producing mill stock, however, showed substantial increase in both quantity and value, more than recovering from the decrease experienced in 1915.

COLORED SLATES.

Sales of colored slates as a whole in the Vermont-New York region in 1916 continued to decrease in value, as is shown in the following table:

Colored slates sold in New York and Vermont in 1909 and 1914–1916.

Year.	Red.	Green.			Purple.	Purple and green, mottled, variegated.	Total.
		Sea-green.	Unfading green.	Green.			
1909	$37,789	$758,372	$133,135	$246,612	$145,041	$443,430	$1,814,379
1914	36,256	789,055	81,884	190,265	121,935	307,628	1,527,023
1915	28,223	672,917	71,765	191,573	88,987	303,199	1,356,664
1916	16,039	529,875	51,328	122,487	265,523	328,154	1,313,406

This continuous decrease during 1914, 1915, and 1916 has been especially marked in the value of red and of the three varieties of green slate. Purple slate, after a considerable decrease in 1915, showed a great decrease in 1916, exceeding the value of 1909, the greatest for which figures are available. The value of mottled and variegated slate also showed considerable increase in 1916, though it was far below that of 1909. These changes in 1916 are explained in part by the fact that one company whose product was green and purple slate in 1915 quarried only purple in 1916, and in part by the increasing popularity of mottled roofing slate.

The prices of these slates tend to vary inversely as their total values. Sea-green slates are the cheapest grade. The mottled or variegated and the unspecified green slates are the next lowest in price. Unfading green, the highest grade of green slate, ranks next, and red slate, the most difficult to work, has the highest price of all. Prices in 1916 and in previous years ranged from about $3 a square for sea-green to about $9 and $10 for red slate. Purple slate, mostly sold for milling, ranks with the variegated and unspecified green slates when sold as roofing. Red and sea-green slates are sold entirely for roofing. The other varieties also are quarried mostly for roofing, only a small quantity being sold as manufactured mill stock.

SLATE INDUSTRY, BY STATES.

The domestic production of slate in 1916, as shown in the tables on pages 63 and 64 was almost entirely confined to the Eastern States. Deposits in Arizona, Arkansas, Colorado, Georgia, and Tennessee remained inactive. Conditions in the producing States are summarized in the following paragraphs.

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CALIFORNIA.

The property of the Eureka Slate Co., which had been idle since 1911, was taken over late in 1915 by a new company, the Western Slate Co. This company after operating a short time and producing a small quantity of roofing slate, was succeeded by the Sierra Slate Corporation, which installed new equipment and expected to begin steady operations in 1917.

MAINE.

Producers in Piscataquis County reported a great improvement in the demand for slate, especially in the last half of the year; but labor and traffic conditions were unfavorable, and one company reported bad quarry conditions that caused curtailment of output. Mill stock, which represents the greater part of the output and which had decreased in quantity and value in 1915, increased markedly in both these respects in 1916. Sales of roofing slate, which decreased in 1915, decreased still further in 1916 in both quantity and value, as shown on page 64, despite an increase in price of $1.38 per square.

The three active companies all reported extension of development work, two of them by underground methods, which are especially suited to narrow deposits of steep or vertical dip.

MARYLAND.

Maryland, whose value of slate sold increased nearly 18 per cent in 1915, showed a decrease of more than 21 per cent in 1916. Sales, as shown on page 64, were entirely of roofing slate, whose average price decreased 3 cents a square. The entire output was from the "Peach Bottom" district in Harford County. Only one producer reported the demand better than in 1915 and in excess of production. Others attributed decline in demand in part to increase in price and in part to physical difficulties encountered in some quarries, including the removal of a large slide that took place in 1915. One company was driving a 900-foot tunnel to develop additional "chambers" and expected to reach the slate deposit by March 1, 1917.

NEW JERSEY.

Only one company in New Jersey produced slate in 1916. The demand was reported to be good.

NEW YORK.

Sales of slate in Washington County, N. Y., after an increase of 13 per cent in value in 1915, showed a decrease of more than 83 per cent in 1916. The reported output has been almost entirely of roofing slate and has included red, green, purple, variegated, and black varieties. A little of the red variety has also been used in the manufacture of paint. As there is considerable difference in price between red and green slate, fluctuation in the marketed production of either causes considerable variation in the yearly average price, but the marked increase in average price and the great decrease in quantity and value in 1916, as shown on page 64, indicate a decline in sales of nearly if not quite all varieties.

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In spite of this great decline, two companies reported a better demand and higher prices than in 1915, the higher prices offsetting increase in wages. Three companies reported commencement of new developments early in 1917. Two of these companies are producing ground and pulverized slate and the third reports manufacture of special grades of roofing slate from a quarter of an inch to an inch thick at an average price of $15 per square.

PENNSYLVANIA.

The value of slate sold in Pennsylvania, after decreasing 16 per cent in 1915, increased nearly 3 per cent in 1916. It amounted to 58.5 per cent of the total value of the country in 1916, somewhat lower than the proportion in 1915. There were 81 companies reported active in 1916, the same as in 1915. In spite of a decrease in 1916, the quantity of roofing slate sold in that year was nearly 64 per cent, and the value 60 per cent of the corresponding totals for the country, compared with 59 and 57 per cent, respectively, in 1915. Although the quantity of mill stock sold, exclusive of blackboards and school slates, was increased in 1916, it amounted to 69 per cent and the value to 52 per cent of the corresponding general totals, compared with 78 and 62 per cent, respectively, in 1915. As already shown on page 62, nearly two-thirds of the value of school slates sold in 1916 represented exports. About four-fifths of the total quantity of slate produced in Pennsylvania is quarried, as shown on page 68, in Northampton County. Nearly all the remainder is quarried in Lehigh County.

Of 63 producers in Pennsylvania who commented on business conditions in 1916, 39 reported a better demand than in 1915, 15 no material change, and 9 a poorer demand. Some of the first group said the general demand was 25 per cent better, especially for mill stock, whereas that for roofing slate was dull. A very few reported improved demand for both roofing slate and mill stock. Scarcity of labor especially affected the industry and was given by several as the principal cause of curtailed production and even of temporary idleness. Wages were higher and, with other increased costs of operation, were chiefly responsible for the increases in price in Northampton and Lehigh counties. One company's output was curtailed because of a rock slide in the quarry.

Six companies reported the stripping of new ground to be worked in 1917. Another reported the opening of a new shaft. Activity was renewed at two quarries after several years of idleness, whereas four quarries ceased operations temporarily or permanently.

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Slate sold in Pennsylvania in 1915 and 1916.

County.	Number of operators.	Roofing slate.			Millstock.								Other (value).	Total value.
					Manufactured.		Rough.		Blackboards.		School slates.			
		Number of squares. (100 square feet).	Value.	Price per square.	Quantity (square feet).	Value.	Quantity (square feet).	Value.	Quantity (square feet).	Value.	Quantity (number).	Value.		
1915.														
Lancaster	1	8,034	$45,239	$6.00										$45,239
York ("Peachbottom slate")	3			5.60										
Lehigh	26	113,911	401,345	3.52	334,409	$37,366	140,493	$15,860	905,190	$78,244	3,310,423	$25,861	$1,421	560,097
Northampton	51	452,278	1,695,589	3.75	2,653,463	441,888	427,033	16,758	2,247,575	271,715	1,533,009	12,306	677	2,438,933
	81	574,223	2,142,173	3.71	2,987,872	479,254	567,526	32,618	3,152,771	349,959	4,843,432	38,167	2,098	3,044,269
1916.														
Lancaster	1	3,903	20,780	6.00										20,780
York ("Peachbottom slate")	3			5.23										
Lehigh	24	98,471	367,806	3.74	421,600	46,845	132,012	13,265	706,046	76,147	2,674,042	33,495	1,995	529,553
Northampton	53	428,968	1,667,738	3.89	2,975,804	529,185	501,365	30,192	2,476,113	327,355	2,315,365	19,066	874	2,574,410
	81	531,342	2,056,324	3.87	3,397,404	576,030	633,377	43,457	3,182,159	403,502	4,990,007	52,561	2,869	3,124,743

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UTAH.

The quantity of slate "waste" sold from the quarry of the Utah Slate Co., near Provo, increased considerably in 1916. This was used in combination with asphalt to make sheets, about 12 by 16 inches in size, for roofing. The market for roofing slate and mill stock was reported to be good, though this statement was not verified by Utah's production in 1916.

VERMONT.

Vermont, as usual, ranked second among the slate-producing States and was the only State besides Pennsylvania whose marketed production exceeded $1,000,000 in value. Vermont's sales in 1916 represented 30 per cent of the total value of slate sold in the country, compared with 25 per cent in 1915. The marked increase in value of its sales in 1916 over those in 1915 was due in part to a substantial increase reported by companies operating in both years, and in part to a considerable production of "other slate" that had not been reported in former years. Roofing slate comprised 63 per cent of the total value in 1916.

Of 32 companies that commented on business conditions in 1916, 23 reported a better demand than in 1915, 8 reported no material change, and only 1 implied a poorer demand. Scarcity of labor prevented a few companies from filling all their orders and accounted for decreased quantity and value of sales from some quarries. A strike of two months' duration further curtailed production. The higher price of slate in 1916 was due mainly to increase in wages and in other costs of operating. There were no special reports of new developments.

VIRGINIA.

The value of slate sold in Virginia, after increasing 3 per cent in 1915, decreased more than 21 per cent in 1916. The average price of roofing slate, however, increased from $4.27 to $4.60 a square. The entire output was, as usual, roofing slate. Eight companies reported sales in both 1915 and 1916.

Two companies reported greater demand in 1916 than in 1915, and one reported sales from stocks on hand. The increase in average price was attributed in Virginia, as in other States, to increased cost of production.

EXPORTS.

The value of exports of roofing slate in 1916 was $27,630, a continuance of the great decrease in value of exports since the outbreak of the war in 1914, as is shown in the following table:

Roofing slate exported from the United States, 1913–1916.

1913	$226,413	1915	$46,137
1914	139,125	1916	27,630

England, which had formerly been the largest user of American slates, had no reported imports from this country either in 1915 or 1916. The figures for value of exports of roofing slate for 1915 and 1916, shown in the following tables, were furnished by the Bureau of Foreign and Domestic Commerce, United States Department of Commerce.

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Roofing slate exported from the United States, 1915 and 1916.

1915.

Canada	$31,101	West Indies:	
Mexico	2,710	Cuba	$2,740
Central America:		Dominican Republic	333
British Honduras	68	Dutch West Indies	106
Costa Rica	833	Europe:	
Honduras	28	Italy	251
Nicaragua	27	Scotland	940
Panama	559	British South Africa	2,288
South America:		Australia	2,621
Brazil	75	New Zealand	486
British Guiana	208		46,137
Chile	239		
Colombia	16		
Trinidad	499		
Venezuela	9		

1916.

Canada	$22,200	Europe:	
Central America:		Denmark	$800
Honduras	91	France	14
Panama	145	Spain	7
South America:		Hongkong	442
Colombia	342	Chosen	52
Uruguay	78	British India	46
West Indies:		French Oceania	5
Cuba	57	British South Africa	73
Haiti	110	Portuguese Africa	140
Bermuda	105		27,630
Jamaica	262		
Trinidad and Tobago	2,603		
Other British West Indies	58		

The value of exports of roofing slate from the United States to Canada in 1915 was nearly three-fourths of the total value of exports. Canadian imports of slate in that year are as follows:

Roofing slate	$34,528
School writing slate	38,874
Slate pencils	4,954
Slate of all kinds and manufactures of	30,320
	108,676

In 1916 exports of roofing slate to Canada, although decreasing 29 per cent, represented 80 per cent of total exports of roofing slate. Altogether slate valued at $33,282 was exported to Canada during 1916. The total slate imports of that country for 1916 are not yet available.

Canada's production of roofing slate in 1916 was 1,262 squares, valued at $6,223,[1] compared with 1,075 squares, valued at $4,837, in 1914 [2] and 397 squares, valued at $2,039, in 1915.

No roofing slate was exported to Mexico in 1916, and only a small amount of electrical slate.

[1] McLeish, John, Preliminary report of the mineral production of Canada during the calendar year 1916, Canada Dept. Mines.

[2] McLeish, John, The production of cement, lime, clay products, stone, and other structural materials in Canada during calendar year 1915, Canada Dept. Mines.

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Besides the exports of roofing slate as given in the preceding table, the following figures showing exports of slate for other purposes than roofing were compiled from information furnished directly to the United States Geological Survey by manufacturers and producers. These figures were collected for the first time in 1916, and it is possible that they are not complete, especially with reference to exports of slate for electric purposes and for billiard and pool tables.

Slate other than roofing exported in 1916.

To—	Quantity.	Value.	Producing State.
Canada:			
Electrical		$5,003	Maine.
Structural, square feet	1,000	1,500	Pennsylvania.
Blackboards, do	8,000	1,200	Do.
Electrical, do	653	203	Vermont.
Billiard tables, do	65	20	Do.
Electrical, do	120	90	
School slates, cases	643	3,066	Pennsylvania.
Newfoundland:			
Electrical, square feet	200	150	
Mexico:			
Electrical, do	480	360	
Central America:			
Unspecified:			
Electrical, square feet	40	30	
Billiard tables, slabs	75	875	Vermont and Pennsylvania.
Panama:			
Electrical, square feet	840	630	
Slabs		1,000	Pennsylvania.
West Indies:			
Unspecified:			
Billiard tables, slabs	120	1,400	Vermont and Pennsylvania.
Cuba:			
Sanitary slate, square feet	2,531	676	Pennsylvania.
School slates, cases	332	1,463	Do.
Electrical, square feet	3,200	2,400	
Porto Rico (San Juan):			
Blackboards and sanitary slate, do	3,100	800	Do.
South America:			
Unspecified:			
School slates, cases	2,208	9,955	Do.
Billiard tables, slabs	195	2,315	Vermont and Pennsylvania.
West coast:			
Electrical, square feet	900	675	
Argentina:			
Electrical, do	300	225	
Brazil:			
Electrical, do	240	180	
Colombia:			
Electrical, do	200	180	
Venezuela:			
Electrical, do	20	15	
Europe:			
Unspecified:			
Electrical, do	1,020	765	
Great Britain:			
Electrical, do	20	15	
France:			
Electrical, do	620	465	
Greece:			
School slates, cases	23	1,804	Pennsylvania.
Italy:			
Electrical, square feet	960	720	
Spain:			
School slates, cases	49	233	Do.
Denmark:			
Electrical		2,218	Maine.
Norway:			
Blackboards, square feet	5,317	780	Pennsylvania
Scandinavia:			
School slates, cases	172	609	Do.
Russia:			
Electrical		107	Maine.
Do, square feet	1,360	1,020	
Africa:			
Unspecified:			
School slates, cases	393	1,921	Pennsylvania.
South Africa:			
Electrical, square feet	100	75	

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Slate other than roofing exported in 1916—Continued.

To—	Quantity.	Value.	Producing State.
Asia:			
China:			
Electrical.....square feet..	200	$150	
Central Asia (except China):			
Electrical.....do....	280	210	
Japan:			
Electrical.....do....	2,640	1,980	
India:			
School slates.....cases..	937	2,573	Do.
Philippines:			
Electrical.....square feet..	160	120	
Billiard tables.....slabs..	15	175	Vermont and Pennsylvania.
Dutch East Indies:			
Electrical.....square feet..	20	15	
Australia:			
School slates.....cases..	355	1,536	Pennsylvania.
Electrical.....square feet..	2,200	1,650	
Unspecified:			
Blackboards.....	.....	100	
		53,652	

Over 53 per cent of the total value of slate exported for other purposes than roofing in 1916 was represented by slate from Pennsylvania. Nearly all the remainder represented slate from Maine and Vermont. Nearly one-half of this total value of exports was represented by school slates. Slate for electrical purposes, principally switchboards, represented about two-fifths of the total value. The value of this slate is about doubled after preparation for switchboard use. If, therefore, the value of the finished slate is considered instead of the value of the slate as it is purchased by the manufacturers of electrical supplies, the total value of slate exports would be considerably greater than the total recorded in the table. Exports of blackboards and structural slate and slate for billiard tables exceeded $4,000 in value.

Exports from Great Britain,[1] which ranks next to the United States in production of slate, were 17,601 tons in 1913, 9,949 tons in 1914, 4,087 tons in 1915, and 8,075 tons in 1916. The value for 1916 was £38,867, or about $194,335.

IMPORTS.

Imports of slate for consumption into the United States, which have for many years been insignificant, had the following total values during the last three years: $4,855 in 1914, $2,768 in 1915, and $2,200 in 1916. Imports from Great Britain[2] amounted in 1916 to 47 tons, valued at £197, or $985, shipped in October to the Atlantic coast.

[1] Slate Trade Gazette, October, 1916, p. 97.

[2] Idem, November, 1916, p. 112.

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POTASH.[a]

By HOYT S. GALE.

INTRODUCTION AND SUMMARY.

The manufacturers of potash salts and potash products in the United States reported a production in 1916 of 35,739 short tons, having a mean content of about 27 per cent potash (K_2O) and a total content of 9,720 short tons of potash (K_2O). This is almost exactly ten times the production reported for 1915.

Practically all the predicted possibilities as to potash found some fulfillment in 1916. The almost entire stoppage of supplies from abroad and the small stocks on hand with which to meet the requirements have at times carried the price of potash to a high figure. Much potash has been used as fertilizer, even under these conditions, and a quantity of high-grade sulphate produced in this country has been exported to Cuba to meet a special agricultural demand there.

The forms in which potash has been produced and marketed are so diverse that it is difficult to make a summation of the production that will have any real significance. Therefore, the reports for all forms have been reduced to terms of tons of actual available or water-soluble potash (K_2O), the standard commercial unit by which the potash value of these products is usually expressed.

Summary of potash produced in 1916.

Source.	Available potash (K_2O).	
	Quantity (short tons).	Value at point of shipment.
Natural salts or brines	3,994	$1,937,600
Alunite and silicate rocks, including recoveries through furnace dust	1,850	715,000
Kelp	1,556	781,100
Wood ashes (potashes, pearlash)	[b] 412	270,000
Distillery waste (molasses)	1,845	500,900
Miscellaneous organic sources	63	38,130
	9,720	4,242,730

[a] The writer gratefully acknowledges the assistance of Miss Margret R. Nourse in collecting the data on which this report is based and in handling the Geological Survey's voluminous correspondence on potash. The summary of activities in 1916, here given, is based on the field knowledge of the writer, which has been supplemented by published matter and by information obtained through correspondence.

[b] The reported production from wood ashes amounted to 825 tons of salts of varying grades, containing, by a moderate estimate, 50 per cent of potash.

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The foregoing table does not include the many fertilizer materials previously on the market, some of which are largely or chiefly valued for their content of potash and whose price has risen accordingly in the market. It shows the quantity and value of potash salts and other products marketed during the year which were produced chiefly for their content of potash. The distinction between these products and the fertilizer materials just mentioned is that these products were manufactured primarily because of the need for potash.

The largest output has come from the alkali lakes in western Nebraska, which have afforded the most readily available supply of moderately high-grade potash salts obtained by direct drying of the raw material, with perhaps as few technical complications as could be involved in any chemical operation. The great deposit at Searles Lake is only just being brought to the producing stage, the project there having undergone many reverses, technical and otherwise. The production from alunite has been rather regular, but has shown little expansion. Some progress has been made in the extraction of potash from silicates, at least one plant having made and marketed a special product. A large quantity of feldspar has been mined, ground, and so treated that a small percentage of its potash was rendered soluble and so available for use in fertilizers, but none of it is included in the figures for 1916, as little of it was marketed in that year. So far as known, no leucite rocks or mica or sericite schists or similar rocks having a large content of potash have yet yielded any commercial water-soluble salts.

Potash has been produced from several kinds of organic materials. The efforts to obtain potash and potash fertilizers from kelp have been widely published and have been to a certain extent successful. High-grade potash fertilizer salts have been made from molasses distillery wastes in quantities that exceeded the production from kelp. The manufacture of potash from wood ashes by the old-time methods continues to make a small but significant contribution to the total production.

SIGNIFICANCE OF THE DEVELOPMENT.

Much of the present production of potash is maintained by the war prices and can not be continued after these prices fall. Some of the projects may be permanent, but unfortunately their output is yet small. The only exception, perhaps, is Searles Lake, which now bids fair to produce enough potash to take the edge off the market by supplying the most urgent requirements for home consumption, such as those of the chemical industries, but the operation of the Searles Lake deposits is hardly yet under way. So far as is now evident, there is probably no domestic source adequate to supply more than a small percentage of the domestic consumption, but the slight promise should not by any means exclude all hope of larger success.

The activity of private initiative in the development of possible sources of potash is increasing. Interest in the possible recovery of potash as a by-product is very keen, and some of these sources, such as the dust of cement and blast furnaces, seem to offer much promise of development on an extensive scale but are not yet far enough advanced to warrant confident prediction that they will ultimately supply the country's whole needs. Perhaps the real hope of making

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the country independent of foreign supplies lies in the possibility of discovering, in association with some of the very extensive and little-known domestic deposits of salt, a supply of potash that may compete with the foreign supply on equal terms. There are valuable deposits of potash in the Permian in central Germany, in the Oligocene (Tertiary) in Alsace, the lower Miocene (Tertiary) in Galicia, and in the supposed Eocene or Oligocene (Tertiary) in northeastern Spain, all accompanied by deposits of common salt, dolomite, and gypsum, and it would be strange if deposits of this sort were confined entirely to Europe.

Governmental agencies have served and are still serving a useful purpose in aiding development. They have led the search for possible sources of raw materials of all kinds, and by publicity they have stimulated an interest which has undoubtedly produced good results.

IMPORTS.

Potash salts imported and entered for consumption in the United States, calendar years 1912–1916.

Basic potash salts.

Year.	Chloride (muriate).		Sulphate.		Carbonate, crude.		Nitrate.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1912	241,665	$7,229,121	49,119	$1,783,846	3,813	$234,868	3,256	$202,899
1913	231,631	7,075,745	44,349	1,677,429	4,858	272,973	4,826	261,070
1914	185,761	5,745,385	40,224	1,557,224	4,663	265,158	1,115	74,869
1915	64,670	2,296,606	12,708	664,484	2,693	191,621	3	400
1916	1,299	348,961	1,693	81,684	341	113,413	5,769	1,519,375

Miscellaneous manufactured products.

Year.	Caustic.		Cyanide.		All other salts.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1912	4,845	$370,506	363	$109,434	8,429	$761,611
1913	4,324	342,056	735	216,844	9,534	959,595
1914	3,642	285,739	209	59,278	7,295	756,320
1915	1,016	100,035	436	134,123	3,752	377,955
1916	242	16,694	1	803	1,243	271,518

Potash fertilizer salts.

Year.	Kainite.		Manure salts.		Year.	Kainite.		Manure salts.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.		Quantity (short tons).	Value.	Quantity (short tons).	Value.
1912	573,413	$2,396,362	192,368	$1,797,057	1915	7,475	$95,440	15,403	$200,584
1913	521,176	2,201,730	250,529	2,245,509	1916	40	1,173	1,249	21,273
1914	351,566	1,561,115	189,245	1,846,475					

The figures in this table were obtained from the reports of the Bureau of Foreign and Domestic Commerce, United States Department of Commerce, by recalculation to short tons and by giving the

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total for calendar years instead of fiscal years. The tons are calculated to the nearest even unit and the values are those given in the original, so that the value given for a high-priced commodity received in small quantity may not be strictly applicable to the quantity given. For instance, 2,705 pounds of cyanide received in 1916 is reported as 1 ton, but the value given is that of the actual amount received.

Practically all the potash used in this country has normally come from Germany. In addition to the potash materials used as ingredients of fertilizers, such as kainite and manure salts, almost the entire supply of the commercial salts—chloride (muriate) and sulphate—was received directly from German ports until 1914, only a small quantity finding its way through Belgium and the Netherlands. In 1914 these imports were greatly reduced, and at the end of January, 1915, they were practically ended by the promulgation of an embargo on the export of potash from Germany. The large imports reported from Germany in 1915 doubtless consisted of potash shipped from that country in January, before the embargo went into effect, or of German potash gathered by vessels en route or from supplies in storage in other parts of the world. Odd lots of potash came in during the latter part of 1915 from many sources in Europe, North America, and South America, and even from Asia and Africa. The same condition existed during 1916, except that the imports from Germany were entirely shut off, and the odd lots seem to have been derived from sources even more remote. It appears that the stocks of German potash salts throughout the world, outside of Germany and the central allied countries, are nearly exhausted.

The situation in regard to nitrate of potash is somewhat different, as normally a part of this salt is derived by manufacture from Chilean nitrate and German potash, largely in Germany, and another considerable part is shipped from India, where it is obtained from the "saltpeter plantations." In 1913 the supply, in round numbers, was 2,500 tons from Germany as against 3,000 tons from India; but in 1914 only 60 tons came from Germany and 1,700 tons from India; and both sources of supply were practically cut off in 1915. During 1916 somewhat more than 2,500 tons of saltpeter came from India to the United States, both directly and by way of England, doubtless by some special arrangement for the manufacture of munitions.

The following table, representing approximately the total consumption of potash in the United States, is taken from a report on the fertilizer industry prepared by the Federal Trade Commission,[1] and from a statement by H. A. Huston,[2] representing the German Kali Works (Inc.), in New York.

Potash imported, 1905–1914.

	Short tons.		Short tons.
1905	129,084	1911	274,446
1906	155,974	1912	253,678
1907	144,351	1913	267,970
1908	136,057	1914	171,798
1909	173,220		
1910	279,780	Average for 10 years	198,636

Total cost, including freight at American ports, about $10,000,000 a year.

[1] Report on the fertilizer industry, p. 115, Aug. 19, 1916.
[2] Real facts about potash: American Fertilizer, p. 30, Nov. 25, 1916.

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ORIGIN AND MEANING OF THE TERM POTASH.

In 1848, Knapp[1] wrote: "Potashes are never obtained by a chemical decomposition of any other potash salts or as a product ready formed in nature, but always from the ashes of plants." This conception had long been accepted as a fact, but was soon afterwards entirely changed by the exploitation of the salts at Stassfurt in north-central Germany. The methods of producing potash from wood ashes, yeast, the lees of wine, the residue of brandy distilleries, and other sources were crude. The total production of potash in all forms in those days was not great.

The name "potash" was first used because this substance was originally prepared by evaporating the solution of ashes of plants in iron pots, and the name thus originally designated a particular product, mostly an impure potassium carbonate, derived from ashes, but was afterwards used to include caustic potash (lye), obtained by treating the crude carbonate with lime. The original potash of trade was and still is marketed in various grades as stone-ash, an impure mixture of caustic and carbonate; as potash, or black salts, or black flux, and as the redissolved and refined material known as pearlash.

Although potassium had long before entered commerce in considerable quantity as Indian saltpeter, this was not ordinarily called potash. Not until 1860 to 1862[2] did the great deposits about Stassfurt begin to produce potash, and from that time the meaning of the term potash has gradually been extended to cover other commercial compounds of potassium. The deposits at Strassfurt now form the world's chief source of potassium salts, Indian saltpeter, and potash made from wood ashes by old-time methods having been until now about the only other sources of soluble potassium-bearing compounds.

Thus potash is a trade term that was at first applied to some salts of potassium and later extended to cover others. Potassium is a metallic element that is chemically closely related to sodium. Combinations of the metal potassium and certain acids produce salts of potassium—the chloride (muriate), sulphate, carbonate, nitrate, and other salts. The salts of potassium closely resemble the corresponding salts of sodium. Pure potassium chloride (muriate), for example, much resembles sodium chloride or common salt in color, crystallization, and other properties, as well as in taste, which is salty though slightly sharper. However, the trade in its terminology still associates potash with carbonate and lye. A combination of potassium carbonate with caustic lime produces caustic potash or lye (potassium hydrate). If this hydrated potash is heated so as to drive off all water the product is potassium oxide or "pure potash" (chemical symbol, K_2O). Potassium oxide has been adopted as the unit of measurement of all the potash salts; that is, the unit of measurement of the value of a potassium compound is the calculated equivalent of the pure potash (K_2O) contained in the salts or mixture. The following table shows the "pure" or "actual potash" equivalent of the common potash salts, assuming that they are themselves chemically pure.

[1] Knapp, Chemical technology, 1st Am. ed., vol. 1, p. 285.
[2] Buschman, J. O. F. von, Das Salz, vol. 1, pp. 131–132, Leipzig, 1909.

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Potash contained in the common salts of potassium.

Salt.	Symbol.	Percentage of potash (K_2O) equivalent to content of potassium.
Potassium chloride (muriate)	KCl	63
Potassium sulphate	K_2SO_4	54
Potassium nitrate	KNO_3	47
Potassium carbonate	K_2CO_3	68

The marketed salts are seldom even approximately pure, but are ordinarily designated by terms indicating the degree of refinement. For instance, one of the standard salts of commerce is the "80 per cent muriate," equivalent to about 50 per cent potash (K_2O). Many of the fertilizer salts, such as kainite and manure salts, are mixtures, not always of the same composition but guaranteed to contain certain specified percentages of potash (K_2O).

GENERAL DISTRIBUTION OF POTASH.

Potash occurs principally in the rocks and soils of the earth, where it is very widely distributed. Chemical analyses of rocks and soils show that potash (K_2O) forms from 2.65 to 3 per cent of the entire earth's crust. Most of it occurs in combinations that are insoluble or only slightly soluble in water, and so is not considered "available" for use either in agriculture or in many large industries that utilize salts of potassium.

From 10 to 15 per cent of certain minerals, some of them, such as feldspar, very common, consists of insoluble potash. Potash in soluble form constitutes a small percentage of the salts in certain waters and brines. It occurs as chloride or possibly sulphate in ordinary sea water; in smaller proportions in the waters of most streams and lakes, and in larger proportions in many natural brines. It is also a constituent of most natural salt or saline deposits, usually a small percentage, but not uncommonly it forms 1 per cent of the whole.

Soluble potassium salts occur in more than ordinary abundance in a number of natural deposits. Preeminent among these are the well-known deposits in north-central Germany, from which now come practically all the world's supply. Other similar deposits occur in Alsace, in Galicia, and in Spain. Minor deposits of various sorts are found all over the world; for instance, some potassium nitrate is found in the saltpeter field of Chile, and alunite is worked in this country and in Italy and Australia as a source of alum and potassium sulphate.

Potash is a constituent of most plants. It forms a part of the liquid contents of the cells and vessels, where it occurs in organic salts. When the plant is burned it appears in the ashes mostly as carbonate, and is similarly released by any form of decomposition. Potash is also a common constituent of animal tissues.

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USES OF POTASH.

Agriculture and other industries.—The greater part of the potash consumed in this country is used as fertilizer. Of the various elements essential to plant growth potassium is one of the few that are likely to become exhausted or deficient in cultivated soils. Used under proper conditions it stimulates plant growth, and for certain crops a special application of it is now regarded as almost essential, a fact illustrated by the present agricultural demand for it even at abnormally high prices.

The need of potash in certain manufacturing industries, however, is pressing. For making the best liquid soap and some higher-grade cake soaps it is essential, and it is also needed in the manufacture of some of the better grades of glass. It is absolutely necessary in the manufacture of certain explosives, though the great bulk of modern explosives are made without potash. Potash is now used extensively in matches, and there are many particular applications of its salts in other industries. On the whole the chemical requirements, though they consume only relatively small quantities of potash, are the most urgent of all, and in any abnormal restriction of supply they are the first to be provided for.

Soap and laundry.—In 1909 there were 883,582 short tons of hard soap and 30,018 short tons of soft soap made in the United States.[1] Soap makers use caustic potash, particularly for the finest soaps; they use caustic soda for the common grades. Potash is the basis of soft soap, which has been favored for its distinctive cleansing power, and now the increasing popularity of liquid soap, especially for use in public lavatories, has created an additional demand for potash. It is used in shaving soaps and in shampoo preparations. Probably not all the liquid soaps now on the market are pure potash soaps, as it is believed that some are made by solution of commoner grades in some solvent.

Caustic potash has been required in considerable amount for use in laundries. Applied in solution so dilute as not to injure fabrics, it produces with soap a ready suds, attacking and removing grease.

Manufacture of glass.—The potash used in the manufacture of glass is known as hydrated potassium carbonate. In years of normal production about 3,000 short tons of this material, valued at about $250,000, has been imported, principally from Germany, for making glass of the highest grades, especially for cut glass, incandescent electric light bulbs, optical glass, and other forms.

Formerly wood-ash carbonate was purified for glass manufacture, which requires a potash entirely free from sulphate. The composition of the hydrated carbonate approaches $K_2CO_3.2H_2O$, thus containing 12 to 18 per cent of water. Potash, or pearlash, is more effective than soda in facilitating the fusion of glass and, what is even more important, it gives no color. The normal price of glassmakers' carbonate was about 4 cents a pound, but it had risen to at least 45 cents in the later part of 1916. A fair grade of glass can be made without potash, but the substitute costs more and is not so good. The cut-glass industry is therefore very dependent on a supply of potash.

[1] Thirteenth Census of the United States, 1910, vol. 10, Manufactures, p. 673, 1913.

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Matches.—Since the passage of the nonpoisonous-match act of 1913 the old white phosphorus matches have been replaced almost universally by matches whose prime igniting ingredient is a nonpoisonous sesquisulphide of phosphorus, combined with one or more substances that readily yield oxygen on being heated by friction. Chief among these oxygen-yielding substances is chlorate of potash, though red lead, nitrate of lead, potassium bichromate, and peroxide of manganese are also used. It is estimated that about 250,000,000,000 matches are annually used in the United States. These are manufactured by some 25 establishments, the Diamond Match Co. producing about 60 per cent of the output. If the bulk of the matches used are of the chlorate of potash type, which is believed to be the fact, this use involves a considerable consumption of potash. For the manufacture of matches, therefore, potash is highly desirable, though doubtless not absolutely essential.

Explosives.—The principal explosives now in general use may be divided into two classes—charcoal powders and nitrocellulose powders. Brown charcoal powder or brown powder is now obsolete, but black charcoal powders are still used. The charcoal powders are made of sulphur, saltpeter (potassium nitrate), and charcoal, and although sodium nitrate is frequently used instead of saltpeter in blasting powder, potash is one of the essential constituents of the best black powders. Ordinary black powder is composed of saltpeter, 75 per cent; charcoal, 15 per cent; and sulphur, 10 per cent. In order to bring these ingredients into intimate contact they are pulverized, thoroughly mixed, and compressed into cakes, and the cakes are then usually broken or granulated.

Black powder is still used chiefly where slower action than that of other powders is desired. It is one of the forms of common blasting powder; it is used for filling fuses, for some sporting powders, for signal lights, for fireworks, for saluting charges, as an igniter for nitrocellulose powders, and as mealed powder in primers. Its greatest present military use, perhaps, is for the bursting charge of the slower-acting shrapnel.

Potassium chlorate is a constituent of some powders, but it is supposed that the corresponding sodium salt may serve as well, although positive data on this point are not now at hand. This salt is the oxidizing ingredient in signal and pyrotechnic mixtures, being usually combined with sulphur and some metallic compound to give the desired color to the flame.

Tanning.—"Chrome" or mineral tanning of leather, said to be of American origin, is now extensively practiced. After being fully prepared for tanning the skins are immersed in a bath containing a solution of potassium bichromate and muriatic acid, after which they are treated in a second solution of hyposulphite of soda. Chromic oxide unites with the fiber of the skin, converting it into leather.

Dyeing.—Potash or other salts of potassium are ingredients of many substances employed in dyeing; for instance, potassium ferricyanide is used in Prussian blue. Potassium bichromate is also used as a mordant or fixer; it is the one most largely used in dyeing wool.

Metallurgy.—Potassium cyanide has been largely used in the cyanide process as a solvent in extracting gold from finely ground ores.

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It has been found, however, that with certain adaptations to suit the change sodium cyanide serves as well.

Electroplating.—Caustic potash is used for removing grease from metallic surfaces before they are electroplated. As a solvent for gold and other metals potassium cyanide is used in solutions employed in electroplating.

Photography.—In the forms of various chemicals potassium is used, though presumably in small quantities, in various processes of photography, both in developing and in printing. Blue-print paper, for example, is made from potassium ferricyanide, or red prussiate of potash.

Medicinal and miscellaneous chemical uses.—The medicinal uses of potassium are various, as are also the minor chemical uses of the many different compounds of potassium, which in the aggregate probably involve a small consumption of potash salts.

PRICES.

A review of the history of the German potash syndicate and of the contracts that have been made with it for potash salts shows the low prices at which these salts could be sold by this syndicate if it should be compelled to compete with other sources of supply. In this connection the prices given in the so-called Schmidtmann contracts with several American fertilizer companies in 1909 are illuminating. These contracts covered a period of two years, gave a privilege of renewal for five years more, and called for deliveries of not less than 27,000 tons of potash (K_2O) annually, so that the rates were not "cut prices." It is asserted that the Schmidtmann mines could operate profitably at these prices, although this may not be true for most of the German potash mines. The following table shows the Schmidtmann prices and in comparison the syndicate prices that were afterwards established:

Wholesale prices per net metric ton of potash salts, c. i. f. Atlantic ports, 1910.

Potash salts.	Schmidtmann prices, 1910 and 1911.			Syndicate prices, January–June, 1910.		
	F. o. b.	Additional charges (bagging, insurance, etc.).	C. i. f. Atlantic ports.	List.	Three per cent discount.	Net.
Concentrated salts:						
Muriate	$15.54	$4.86	$20.40	$34.00	$1.02	$32.98
Sulphate	20.94	4.86	25.80	40.00	1.20	38.80
Double manure	9.28	4.86	14.14	21.00	.63	20.37
30 per cent manure	8.42	4.86	13.28	.....	.....	.....
Crude salts:						
Kainite, 12 per cent guaranty	1.92	3.24	5.16	7.25	.22	7.03
Hartsalz	2.48	3.24	5.72	9.00	.27	8.73
20 per cent manure	3.89	3.24	7.13	12.00	.36	11.64

Thus one of the more efficient mines can produce a 50 per cent K_2O muriate at about $15 a ton and kainite with a guaranteed minimum of 12 per cent K_2O at less than $2 a ton at point of production.

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The prices of German potash salts delivered at Gulf and Atlantic ports before the outbreak of the present war were as follows:

Prices of German potash salts, 1912–1914.

	1912-13	1914
Muriate of potash (80 per cent KCl; 50 per cent K_2O)	$38.05	$39.07
Sulphate of potash (90 per cent K_2SO_4; 48 per cent K_2O)	46.30	47.57
Manure salts (20 per cent K_2O)	13.30	13.58
Kainite (12.4 per cent K_2O)	8.25	8.36

A discount of 15.5 per cent from these prices was granted to purchasers of large quantities in bulk and 15 per cent in bags. The ocean freights on these salts in bulk from Hamburg average about $2 (8 to 9 shillings) per metric ton on liners to northern ports and $2.50 to $2.90 (10 to 12 shillings) to southern ports, where most of the shipments go.

Since the embargo of January 30, 1915, placed on the exportation of potash salts from Germany the prices of these salts have risen enormously. During 1916 the prices of potash-bearing fertilizer have been quoted on a basis of an established unit per cent per ton of available or water-soluble potash, and quotations have ranged from $3 to $3.50 per unit at the point of production, although reports of prices as high as $5 and $6 per unit have been received. An 80 per cent muriate (50 per cent K_2O) would therefore bring at least $150 to $175 per short ton at point of production, and there is little doubt that most of the available product was sold above those prices. Actual sales of potash salts since the war began have been made at prices ranging from $80 to $600 a ton, most of them, however, below $400. Since the shipments from Germany were suspended on January 30, 1915, sales of muriate (80 per cent K_2O) have been made at $250 to $600 a ton and of sulphate (90 per cent K_2O) at $120 to $350 a ton.

DEVELOPMENTS AND PROJECTS IN THE UNITED STATES.

POTASH IN NATURAL SALTS OR BRINES.

GENERAL STATEMENT.

Probably every natural deposit of salt or saline material and every natural brine or saline water contains a small percentage of potash, though usually the water-soluble constituents consist in large part of soda or, exceptionally, of salts of other bases. Many reported discoveries of salines high in potash have from time to time been brought to the attention of the United States Geological Survey, but unfortunately in almost every one of them there has been some mistake or misapprehension, so that the deposits have proved to be of no practical value. Many samples sent for analysis contain some potash in both soluble and insoluble forms. Analysis may determine either or both of these forms. Even if the analysis is correctly stated, a small percentage of potash in material found at the surface does not actually indicate that richer deposits lie at depth, as is so often

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reasoned by the optimistic prospector. Sea water contains a small percentage of potash in solution, which it is not ordinarily considered practicable to extract. Under special conditions, however, as by use of by-products recovered from bitterns at the salt plants, potash has been profitably extracted from sea water. Thus, it is impossible to give final judgment as to the ultimate feasibility of recovering potash from any ordinary brine or salt, for potash in soluble and insoluble forms is widely distributed, and its recovery depends on many different factors and considerations.

A review of natural salts and salines with reference to their content of potash is an interesting preliminary step to a consideration of the possible recovery of potash from these sources.

Potash content of some natural salt deposits in the United States.

Locality.	Nature of occurrence.	Analyst.	Percentage of K_2O.
Retsof, N. Y.	Rock salt from working face.	R. F. Gardiner	0.24
Kanopolis, Kans.	Rock salt	do	.12
Salt cliffs, Virgin River Valley, Nev.	Natural salt ledges	R. K. Bailey, average of 5 analyses.	.15
Death Valley, Cal.	Surface salt deposit	George Steiger	.20

Potash content of some natural waters or brines of the United States.

Locality.	Material analyzed.	Analyst.	Percentage of K_2O.
Jesse Lake, Nebr.*	Brine containing about 19 per cent dissolved salts.	J. F. Breazeale	5.96
Searles Lake, Cal.*	Saturated brine	Walton Van Winkle	2.48
Western Nebraska*, (average of 13 alkali lakes).	Brines of various densities	W. B. Hicks and R. K. Bailey.	1.91
Soda Lake, San Luis Valley, Colo.	Saturated brine	W. B. Hicks	1.62
Salduro, Utah*	do	do	1.24
Death Valley, Cal. (average of 14 samples).	Saturated brines	W. B. Hicks and R. K. Bailey.	.59
Great Salt Lake, Utah.*	Brine containing about 20 per cent dissolved salts.	R. K. Bailey	.41
Little Alkali Lake, Oreg.	Brine containing about 11 per cent dissolved salts.	do	.41
Saline Valley, Cal. (average of 5 samples).	Saturated brine	W. B. Hicks and R. K. Bailey.	.35
Owens Lake, Cal.*	Brine containing about 11 per cent dissolved salts.	W. B. Hicks	.28
Utah Hot Springs, 8 miles north of Ogden, Utah.	Water containing about 2½ per cent dissolved salts.	F. W. Clarke	.10
Ordinary sea water* (mean of 77 analyses of ocean water from many localities).	Water containing about 3½ per cent dissolved salts.	W. Dittmar	.04

Brines at the localities marked with an asterisk (*) have been utilized for the extraction of potash in one way or another, and it is evident that the potash content alone does not determine the availability of the material as a source of potash. Many other brines or salts have as high a content of potash as some of these. The economic value of such deposits, therefore (within certain limits), lies not so much in the specific character of the raw material as in the many other factors that bear on or affect its utilization.

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POTASSIUM NITRATE OR SALTPETER.

Ordinary saltpeter or nitrate of potash is very commonly found native, though generally it is not preserved naturally in large deposits. Deposits of this salt form a class quite distinct from most other occurrences of potash, and although it would be entirely appropriate to discuss them in this chapter, the data at hand on the nitrates include so much detail that they will be discussed in full in another publication.

This salt has long been produced artificially by decomposing organic matter in soil, and accounts of its preparation and collection by this means in Switzerland, Sweden, India, and elsewhere are given in the older chemical technologic treatises.[1] In this industry nitrate is produced in "saltpeter plantations" and by leaching natural saltpeter-bearing earths in India, a source which still furnishes a very considerable supply of the potassium nitrate of commerce.

The principal source of the world's supply of nitrate has been the sodium nitrate fields of Chile. Some potassium nitrate is associated with the sodium nitrate, and some attempt has been made to separate and refine potassium nitrate from this source, but much of the potassium nitrate of commerce has been manufactured from Chilean sodium nitrate and potash salts exported from Germany.

Small deposits of nitrate have been found at many places in the United States and many of them have been carefully investigated by the United States Geological Survey. Soluble nitrate salts are commonly found either as incrustations on rocks, usually on overhanging ledges or in caves, or as a constituent of soils.

The incrustations occur as crusts or films on the faces of ledges as seams (most of them thin) in crevices in rocks, and as deposits filling spaces in porous rocks at and near the surface or to a depth of several feet. They are naturally preserved in recesses in rock ledges, where they are sheltered from the dissolving action of mist, rain, or snow water. They are found in many different kinds of rock, in lava ledges, in beds of volcanic tuff or ash, and in limestone and sandstone. Their existence or preservation apparently depends rather on the shattering or porosity of the rock than on its kind or composition. The ledge or cave deposits are of essentially the same type wherever found, although they vary considerably in detail of occurrence. The incrustations are found not only on the faces and in the fractures of ledges of solid or porous rock, but some of them form layers or cementing constituents in the loose soil and rock breccia at the bases of cliffs or lie in places protected from the weather. Some specimens obtained from both these sources are rich in nitrate salts, but analyses of these specimens do not indicate the average percentage of nitrate the rock itself actually carries, and some of them are very misleading as indications of the quantity and value of the deposit. The deposits are evidently surficial—that is, they do not extend far into the mass of the rock—and the quantities of the nitrate salts found are practically insignificant.

[1] For example, see Richardson, Thomas, and Watts, Henry, Treatise on acids, alkalies, and salts, 2d ed., vol. 2, pp. 281–310, 1867. See also Hooper, D., Report on the manufacture and composition of Indian saltpeter: Agricultural Ledger, No. 8, pp. 17–48, Supt. of Govt. Printing, Calcutta, India, 1905.

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Nitrates are found in all fertile soils, but they occur in unusually large quantities in some soils, and particularly in a peculiar series of barren clay hills, those best known being mostly in southern California. These deposits have been examined by many persons, practically all of whom have reached the general conclusion that they can not be utilized commercially. Their content of nitrate, although unusually large as compared with that of ordinary soils, probably does not average more than a small percentage of the soil or clay, and it can probably not be profitably extracted.

POTASH FROM THE ALKALI LAKES OF WESTERN NEBRASKA.

GENERAL CONDITIONS.

The first large production of domestic potash has come from the alkali lakes of western Nebraska. Potash-rich salts and brines are contained in a number of alkali lakes and ponds which are scattered over the sand-hill region of western-central Nebraska, especially in Cherry, Sheridan, Box Butte, Morrill, and Garden counties. The Chicago, Burlington & Quincy Railroad passes through Alliance, Nebr., which is just west of the sand hills.

These ponds range from less than an acre to 2 square miles in size, although the quantity of water in them varies greatly with the seasons. The deeper ponds are comparatively fresh, but many of the shallow ones are strongly brackish or briny. The ponds lie in small inclosed basins, whose lack of external drainage outlet is supposed to be due to the irregular topography formed by shifting sands. Between some of them and adjacent basins and valleys there are low divides, so that a slight rise of their waters would cause them to overflow, though probably in many of them overflow has seldom occurred, as is shown by the accumulation of salts. The soluble salts are mainly collected in the lowest parts of the basins.

The alkali that is concentrated in these ponds was doubtless leached from the adjacent soil. A complete analysis of the saline residue of these deposits shows that they resemble the leachings of wood ashes, which may have been in large part the source of much of this alkali, for the adjoining sand hills were once covered with a generous growth of grass and brush, and the region has been repeatedly burned over. It is not necessary, however, to assume burning in order to account for the release of the potash from the organic matter here, as the potash may have been released by ordinary decomposition. The concentrated leachings from these sources may have formed these deposits, but other views as to their origin are also held, and, indeed, it seems strange that so much potash derived from vegetation should accumulate in water-soluble form only in this part of the country, for similar conditions at many other places have not produced the same result.

At the close of 1916 five projects for producing potash from the brines of the western Nebraska lakes were reported to be well under way, all of them along the Burlington Railroad east of Alliance. They are the Potash Products Co., plant at Hoffland; the Hord Alkali Products Co., plant at Lakeside; the Palmer Alkali Co., plant at Lakeside; the American Potash Co., plant at Antioch; the Nebraska Potash Works Co., plant at Antioch. Hoffland is 11 miles,

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Antioch 15 miles, and Lakeside 24 miles east of Alliance. The general situation of these places and of the deposits from which the raw materials are taken is shown in the accompanying sketch map (fig. 2).

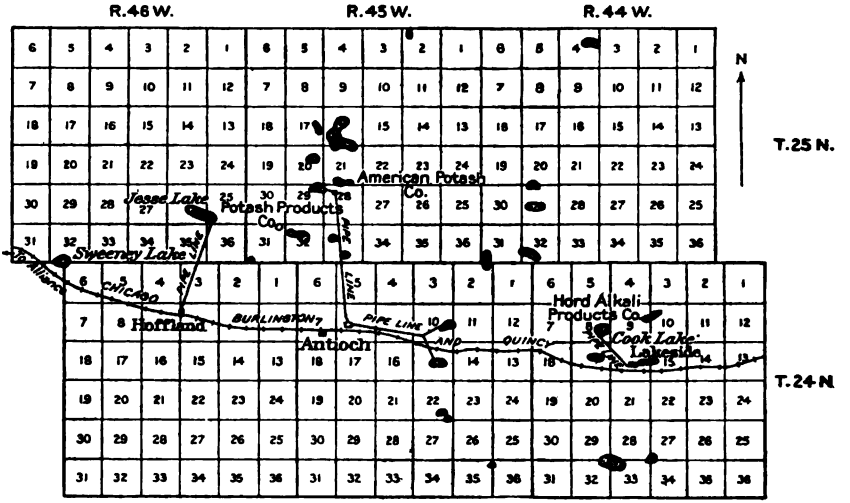

FIGURE 2.—Map showing location of potash plants in western Nebraska.

POTASH PRODUCTS CO., HOFFLAND, NEBR.

The potash in the so-called alkali from these lakes in western Nebraska was first exploited by the Potash Products Co., of Omaha, Nebr. The credit for the investigation and exploitation of these deposits is undoubtedly due to Messrs. J. H. Show and Carl Modesitt, who began to study them at least as early as 1911 and had made plans to utilize the salts commercially before the beginning of the present abnormal demand for potash. It was not, however, until about the middle of 1915 that the company actually started commercial operation. At the close of 1916 this company was advertising that 10,000 tons of high-grade potash had been shipped from their plant in the preceding 12 months, and that the product had an average content of 28 per cent of water-soluble potash (K_2O) and 3 per cent of chlorine.

Jesse Lake, probably one of the largest of these lakes and the one that contained the most alkali, is the source of the brine worked by the Potash Products Co. The lake is about 3 miles north of Hoffland and the brine is pumped directly from the lake to the plant at the railroad. There the water is evaporated and the salts are dried for shipment without refining. The product shipped is therefore essentially of the composition of the original saline content of the lake liquor.

The lake is shallow and covers about 240 acres, varying somewhat in size and depth as well as in concentration of its water with the seasonal evaporation and precipitation. Its bottom is composed of a dark-greenish mud, beneath which is sand charged with brine much like that at the surface. The sand is said to be 20 feet thick in places

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and to rest on hardpan composed of dense, impervious marl rich in magnesia. The brine that impregnates the sand is of a more stable degree of concentration than the surface water and is considered the main source of supply of the alkali liquor. When the plant was visited in October, 1916, it was stated that 200 wells were then being pumped to the limit of their capacity.

The composition of a sample of the salts obtained by evaporating a sample of the lake water taken March 23, 1912, is shown by the following analysis:

Analysis of dissolved solids contained in brine of Jesse Lake, Nebr.

K_2O	30.85	HCO_3	7.74
Na_2O	25.31	Cl	4.07
SO_3	13.77		
CO_2	19.79		101.53

The total solids in solution were reported as 19.32 per cent in this sample, but this is undoubtedly considerably more concentration than the surface water usually shows.

The composition of the surface water is very similar to the waters obtained from the underlying sands. Samples of brines and muds collected by J. H. Hance were analyzed by A. R. Merz at the Cooperative Laboratory at Reno, Nev., with the following results:

Analyses of brines, muds, and residues from Jesse Lake, Nebr.

Brines.

No.	Location.	Percentage of dissolved salts (dried at 105° C.).	Percentage of KO in dissolved salts.
24	Shallow pit at edge of lake	12.31	34.81
27	Pit 4 feet deep, 40 feet from lake shore	14.14	26.40
118	Middle of lake	13.55	29.97

Muds.

26	1 foot below surface, 40 feet from shore	9.35	25.42
115	4 feet below surface	4.63	28.92
116	7 feet below surface	4.07	24.78

Saline residues.

25	Crust on southeast margin of lake	34.06	21.00
117	Surface incrustation	20.25	17.39

The evaporated salts are mostly sulphates, but include a large percentage of carbonates and some bicarbonates formed when the brine is dried at ordinary temperatures.

The following analyses show the composition of the products first put on the market from these deposits, 1 being a dried residue obtained by direct evaporation of the lake water, and 2 the material shipped as a wet salts or slurry, a form in which a quantity of potash was marketed in 1915 and early in 1916.

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Analyses of products from Jesse Lake, Nebr.

[Oswald Schreiner, analyst.]

	1	2		1	2
Na_2O	20.97	17.46	CO_3	17.27	12.9
K_2O	30.49	23.12	HCO_3	.3	2.1
P_2O_5	.27	.21		98.88	77.13
Cl	1.38	1.04			
SO_3	28.2	20.3			

At present the brine obtained from the wells in the lake is dried and no attempt is made to refine it. A part of it is fused and the product is shipped just as it comes from the kiln. The density of the brine from the pumps is said to average about 9° to 10° B. After passing to the plant through the pipe line it is heated and pumped through a solar tower in which it passes by gravity over wooden partitions, ranged one below the other like the slats of a window blind, and by this means is somewhat concentrated by evaporation. It then passes to triple-effect vacuum evaporators, its density at this stage reaching about 30° B. It then passes to a single-effect vacuum pan, where by crystallization of part of the salts its density is raised to about 48° B. It is next passed to cooling and crystallizing vats, where, after standing a few days to permit crystallization of the salts, it is tapped off and returned to the system and the salts are shoveled out.

The wet salts are dried in a rotary drum furnace, where most of the rest of the water is driven off, and are reduced to a dry clinker-like mass carrying 27 to 28 per cent of potash salts and probably less than 1 per cent of moisture. The salts produced are mainly sulphates and carbonates and have lately gone largely into use as a fertilizer that should compare favorably with the corresponding grade of pearlash or wood ashes, which are a favored fertilizer for certain crops or lands.

HORD ALKALI PRODUCTS CO., LAKESIDE, NEBR.

The second company to produce potash from the waters or brines of alkali lakes in western Nebraska is the Hord Alkali Products Co. (Inc.), of Central City, Nebr., whose plant at Lakeside was practically completed, ready for commercial operation, at the close of 1916. The plant is reported to be thoroughly equipped and to represent an expenditure of $60,000 to $100,000.

The plant is primarily intended to recover the potash from the waters, muds, and sands of some of the numerous shallow lakes near Lakeside. The main source of supply now in view is Cook Lake, about a mile northwest of the plant at Lakeside, which is built on the railroad. The lake and plant are connected by a power line and a pipe line.

Here, as at Jesse Lake, the brine is pumped from wells drilled in the lakes to obtain the richer or more uniform brine from the underlying porous strata. The surface water is too dilute except at times of unusually low water.

The brine is to be pumped to the plant, where it will be evaporated and the salts will be dried and sacked for shipment. No

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definite plans have yet been made for the manufacture of purified salts; the product will be shipped crude. The composition of the salts is similar to that of those obtained from Jesse Lake, so that the product will carry about 26 per cent of potash, chiefly sulphate, carbonate, and a little chloride.

PALMER ALKALI CO., LAKESIDE, NEBR.

The plant of the Palmer Alkali Co. is 2½ miles east of Lakeside. The company reported the production of potash in 1916.

AMERICAN POTASH CO., ANTIOCH, NEBR.

Two potash plants were projected at Antioch during 1916, but little data are at hand concerning their operation. The American Potash Co., of Omaha, Nebr., is reported to have obtained leases on several small lakes in Sheridan County, north of Antioch. One of these lakes is about 3 miles north of the railroad at Antioch; another one, somewhat larger, is farther north, on the Crowsey farm. In composition the water of these lakes closely resembles that of Jesse Lake, although doubtless the waters of different lakes differ somewhat. The following is an analysis of water from one of the lakes in this vicinity, doubtless the one that is being drawn on first.

Analysis of alkali lake water 3 miles north of Antioch, Nebr.

K_2O	29.64	Cl	2.73
Na_2O	23.82	SiO_2	1.38
CO_3	15.91		
HCO_3	9.20		99.98
SO_3	17.30		

The residue from the evaporation of 100 cubic centimeters of the liquor weighed 3.4088 grams.

NEBRASKA POTASH WORKS CO., ANTIOCH, NEBR.

The fourth plant underway for the recovery of potash salts from the Nebraska lake brines is that of the Nebraska Potash Works Co., whose main office is at Denver, Colo. The incorporation of this company was announced in March, 1916, with a stated capital of $100,000.

The brine is to be drawn from Taylor Lake, in sec. 10, T. 24 N., R. 45 W., about 3 miles east of Antioch, and the plant is to be built at Antioch, the brine to be conducted to the plant by pipe line, as at the other establishments. No analyses of the water of this lake are now available, but it is understood that it is essentially similar to those already considered, the surface water being possibly not quite so concentrated. Little positive information has been obtained concerning this project, but the purpose is probably to dry and ship the salts according to the plan followed at the other plants.

PUBLICATIONS ON POTASH IN THE ALKALI LAKES OF NORTHWESTERN NEBRASKA.

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Hance, J. H., Potash in western saline deposits: U. S. Geol. Survey Bull. 540, pp. 457–475 (p. 465). First formal publication on the subject.

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1915. Ziegler, Victor, The potash deposits of the Sand Hills region of northwestern Nebraska: Colorado School of Mines Quart., vol. 10, No. 3, pp. 6–26, Oct. A comprehensive review.

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SEARLES LAKE, SAN BERNARDINO COUNTY, CAL.

GENERAL FEATURES.

The first regular commercial production of potash salts from the Searles Lake deposit, in California, was made in 1916. The older of the two establishments being erected at this place is not yet at full producing capacity—indeed, is scarcely more than started—but the fact that it has begun to produce potash is in itself an important step forward. A second large plant is now in construction by another company, and as this company also is backed by a responsible and capable management its plant will undoubtedly be producing in 1917.

The Searles Lake deposit has been described in detail in a report published by the United States Geological Survey[1] from which the following brief sketch of its main features is taken.

Searles Lake is really not a lake at all; it is essentially a deposit of crystalline salts, the surface of which is practically dry a considerable part of the year. This so-called lake occupies the bottom of a basinlike valley which in prehistoric time contained a large and deep lake. After this ancient lake had dried, the salts that had been in solution in its waters were left on its bottom; so that now, when nearly all the surface water has disappeared, the most striking feature of the whole basin is the central level plain of white crystalline salts, which covers about 12 square miles. This salt plain is occasionally flooded by storm water, but during the dry season the water rapidly disappears. The salt itself is permeated by a thoroughly saturated brine, which maintains a practically constant level very close to the surface of the salt plain. The surface of this deposit is so level that a few inches of water floods the whole area to practically uniform depth. A shallow spread of water is, however, very commonly driven about by the wind, so that it may occupy one side of the flat for a few hours, and later by a change in direction of the wind, may be almost entirely blown back to the other side.

Around the margin of the central salt crust is a muddy zone or area of mixed salts, mud, and sand. The ground water or brine combined with this muddy mixture renders this zone soft and often difficult or even dangerous to cross. The margin of the deposit thus presents a sharp contrast with the central hard salt-crust surface, which is so firm that it readily supports automobiles or even heavy drilling rigs. The marginal zone of muddy salts rises outward gradually, merging into the sand dunes of the surrounding valley or into the alluvial outwash slopes that extend out into the valley from the foot of the mountain.

[1] Gale, H. S., Salines in the Owens, Searles, and Panamint basins, southeastern California: U. S. Geol. Survey Bull. 580, pp. 251–323, 1915.

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The many wells that have been bored into and through this deposit show that the salts average 60 to 75 feet in thickness, and reach a maximum thickness of about 100 feet. The crystallized mass forms a great somewhat irregular lens which gradually becomes thinner toward the edges. These edges extend far out under the surface of the marginal mud zone, so that the deposit contains a much greater quantity of salts than could be determined prior to the extensive campaign of drilling that has now been carried out. The crystallized salts are evidently disposed in essentially horizontal layers and differ somewhat in composition at different depths in the deposit. The surface consists mainly of sodium chloride and has been called the "halite" zone. At a depth of about 15 feet there is commonly found a layer of an unusual and very distinctive mineral called hanksite, which is found also with many drillings taken from points below this depth. The salts associated with the hanksite contain more or less sulphate, although these also contain much sodium chloride. Toward the bottom of the deposit layers of crystalline sodium carbonate in the form of the mineral "trona" are found, and at the bottom there is usually a layer or zone of "trona." The salts that are thus buried in an underground lake of brine are difficult to get out and no active steps have been taken for their recovery in the solid form.

The brine that permeates the whole deposit is now considered its principal valuable constituent. It is a saturated solution of the crystallized salts, but it contains more potash and borax than they do. It is to a certain extent a natural "bittern" or "mother liquor," although the term bittern is not strictly applicable to a solution that contain no salts of magnesia. It is undoubtedly the liquor that remained after the crystal salts were formed by the natural concentration of the waters from the ancient lake that occupied this basin.

Analysis of salts in brine of Searles Lake, Cal.

Potassium chloride (KCl)	4.02
Borax ($Na_2B_4O_7$)	1.08
Sodium carbonate (Na_2CO_3)	4.26
Sodium sulphate (Na_2SO_4)	6.40
Sodium chloride ($NaCl$)	17.18
	32.94
Total determined	33.30

Probably no satisfactory means has been devised to determine the proportion of brine to crystalline salts in the deposit, but it is undoubtedly large. The salt crust itself is a porous mass through which the brine flows so readily that the proportion of pore space and consequently of brine must be considerable. The original estimate of the Geological Survey that this pore space constitutes at least one-fourth of the volume of the deposit seems to be moderate. Continued pumping has shown only slight changes in the brine level, which quickly readjusts itself.

It may be assumed that a solution in so porous a medium will also adjust itself by diffusion to a more or less uniform composition, and this assumption seems to be borne out by the evidence. Pumping has shown only slight changes in the composition of the liquor obtained, although when much liquor is drawn it must come from dif-

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ferent parts of the deposit. Tests of samples taken from wells sunk to different depths in various parts of the deposit show a marked uniformity in the character of their saline content.

The plans for working this deposit for potash and other salts contemplate pumping the brine as a raw material from which the products are to be manufactured. A number of schemes for recovering the valuable constituents of this brine have been proposed and a few have been actually tried. The products desired are readily separated in the laboratory, but when the attempt is made to work laboratory processes on a large scale many practical and unforeseen difficulties arise, which must be overcome before it can be determined whether or not the products can be made at a commercial profit.

The two companies now established at Searles Lake for the manufacture of potash and other products from the brine of that deposit are the American Trona Corporation and a company, more recently formed, representing an alliance of the Pacific Coast Borax Co. and the Solvay Process Co.

AMERICAN TRONA CORPORATION, TRONA, CAL.

The original potash enterprise at Searles Lake is that of the American Trona Corporation, which was in possession of most of the deposit when its value as a source of potash was first brought to general attention in 1912. The work of this corporation at Searles Lake has been beset with many difficulties. After trial the first experimental plant, established at the station Trona, on the southeast margin of the deposit, was discarded, and further laboratory tests on a considerable volume of brine resulted in the adoption of a new process. In August, 1915, the corporation decided to construct new works at Trona to produce a crude potash salt from the lake brine and a refinery at San Pedro (the harbor of Los Angeles) to refine the salt.

This company's announced intention is to produce at first only potassium chloride and borax, but it may eventually utilize other salts. The concentrating plant at Trona is, according to the plans, capable of treating 400,000 gallons of brine a day. The published report of the company shows that about 120 tons of concentrated potash and borax salts had been produced by October 24, 1916. The estimated normal production of the present plant is 80 tons a day of the ordinary potash and borax salts. When this quantity is treated at the San Pedro refinery it is expected to yield 50 to 60 tons a day of high-grade potassium chloride and 20 tons a day of borax. The crude salts are now being marketed as they come from the plant at Trona.

The brine is believed to be simply evaporated, the first crops of crystals obtained, consisting chiefly of sodium chloride and small quantities of potash and borax, being discarded. The special means, if any, by which the sulphate is eliminated is not generally known, although possibly it is thrown down in the further normal concentration of the brine or by treatment alternately with heat and cold. The mother liquor is dried, the product having approximately the following composition.

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Composition of some of the crude salts first produced at Searles Lake, Cal.

Composition in radicles.

[W. B. Hicks, analyst.]

	Original analysis.[a]	Recalculated to 100 per cent.
K	29.50	33.99
Na (by diff.)	9.58	11.04
Cl	28.70	33.05
CO_3	2.40	2.77
B_4O_7	16.62	19.15
Solids by evaporation	86.80	100.00
Water by difference	13.20	.....

Conventional combinations.

KCl	56.22	64.78
NaCl	4.80	5.53
Na_2CO_3	4.24	4.89
$Na_2B_4O_7$	21.54	24.80
	86.80	100.00

[a] Small amounts of sulphates and probably other constituents were present but not determined.

The company also claims to be producing a natural trona containing

Sodium bicarbonate	12
Sodium carbonate	52
Sodium chloride	6
Water of crystallization	30
	100

The company reports the production early in 1917, among other products, 70 to 80 tons a day of crude salts having approximately the following composition:

Composition of crude salts produced at Searles Lake, Cal., early in 1917.

Potassium chloride	60–70
Sodium chloride	5–10
Sodium sulphate	0.5–1.5
Sodium carbonate	1–3
Anhydrous borax	4–14

Balance: Water of crystallization.

The company also reports a preliminary production and shipment, early in 1917, from the plant at Trona, of very high-grade potassium chloride, 98 per cent pure, which represents the product that will doubtlessly eventually be put out from the refinery at San Pedro.

The following is a published account[1] of the plants at Trona and San Pedro:

The company's plant at Trona, Searles Lake, San Bernardino County, comprises a battery of 2,000 horsepower Babcock & Wilcox boilers, housed in a steel and reinforced concrete building with a vertical flue of steel and con-

[1] Los Angeles Min. and Oil Bulletin, December, 1916.

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crete which is a monument to the designing and constructing engineers. This chimney is 150 feet in height and 9 feet in diameter in the clear at the top. The evaporating building is 109 feet high, 200 feet long, and 70 feet wide, also constructed of steel and concrete. In addition a building 600 by 90 feet houses the machinery for the production of potash salts and borax. The plant also includes a reinforced concrete spray pond for cooling the water used for the condensation of vapors; a 10,000-barrel oil tank; two 500,000-gallon steel tanks for brine; and several other tanks of 10,000 gallons each. The offices and laboratory are in a two-story reinforced concrete building. * * *

The camp equipment is modern in every detail and comfortable bungalows are provided for the employees. A 32-mile standard gage railroad has been completed, operating between Searles, a station on the Southern Pacific, and the company's plant at Trona. The brine is treated at Trona by evaporation and the concentrated product is to be shipped to the refinery at San Pedro. * * *

When completed the refinery at San Pedro, which is not far from Point Fermin, will have a capacity of 200 tons of potash per day and the output will also include a daily production of 60 or more tons of borax. Later the company will put on the market sodium carbonate, sulphate, and chloride, and intends to erect additions to the plant for the manufacture of such potassium or sodium salts as the market may require.

The power plant at San Pedro contains 1,000 horsepower Babcock & Wilcox boilers, housed in a steel and reinforced concrete building, with a chimney of the same dimensions as that at Trona. The principal factory building is 86 feet high, 200 feet long, and 80 feet wide. The office building houses a modern laboratory, drafting, and engineering departments. A warehouse 100 by 300 feet will soon be constructed, also other necessary buildings with machinery for the preparation and sacking of the company's products. It is expected that the refinery will be operating before January 1, 1917. The plant at Trona is, of course, now in operation. Plans are now being made to increase the size and output of the plants at both Trona and San Pedro.

PACIFIC COAST BORAX CO.-SOLVAY PROCESS CO. PLANT, BOROSOLVAY, CAL.

The new potash enterprise at Searles Lake, Cal., is under the joint management of the Pacific Coast Borax Co. and the Solvay Process Co. The plant was expected to be in operation about April 1, 1917.

The Pacific Coast Borax Co. owns the only patented land that covers any part of the main saline deposit at Searles Lake, title having been granted years ago, when borax was supposed to be the only valuable constituent of the deposit. Early in 1916 two tank cars of Searles Lake brine were shipped to the Alameda works of the borax company, where the brine was treated experimentally for the extraction of potash and borax. The results of this test are reported to have been so successful that the new project at Searles Lake was promptly decided on and in October, 1916, work on the new plant was begun.

According to announcements made in newspapers the output of the first commercial unit is to be 40 tons of potassium chloride a day. At first, these reports say, only a 60 to 70 per cent product will be made, but the intention is to increase this standard to 85 or 90 per cent. There are also reports concerning the erection of additional units as soon as the first is in working order. During the present period of high prices of potash salts no attempt will be made to manufacture or market the other salts in the Searles Lake brine, but ultimately a considerable output of borax and soda ash is contemplated.

So far as known no authorized statements have been given out concerning this work, but the project may be regarded as an important one, for it is backed by concerns that have had long experience in making chemical products.

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——— The legal battle for title to potash lands in Searles Lake: Eng. and Min. Jour., vol. 101, p. 277, Feb. 5.
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——— Potash plant at Searles Lake: Eng. and Min. Jour., vol. 102, p. 578, Sept. 20.
——— Searles Lake potash, Min. and Scientific Press, Oct. 7, p. 518.
——— Birth of the potash industry in the United States: Min. and Oil Bull., Los Angeles, vol. 3, No. 1, pp. 297–8 and 316, Dec.
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POTASH PLANTS AT GREAT SALT LAKE, UTAH.

GENERAL CONDITIONS.

Two establishments intended primarily for separating and refining potash salts from the water of Great Salt Lake have now been built, and one of them was in more or less regular operation in 1916. They are the Utah Chemical Co., whose plant is at "Potash Siding" on the branch of the Salt Lake Route from Salt Lake City to Saltair, and the Salt Lake Chemical Co., whose plant is at Grants, a station on the Western Pacific Railroad about 30 miles west of Salt Lake City. The Utah Chemical Co. was organized to recover potash as a by-product from the waste liquors of the salt works near which its plant stands, and the Salt Lake Chemical Co. was designed to handle the lake water directly without consideration of the possible utilization of the salt it contains.

The water of Great Salt Lake is a strong solution of sodium chloride and other salts, and it contains potash in about the same proportion to its other constituents as does sea water. It carries about 20 per cent of dissolved salts, however, whereas sea water carries only 3.5 per cent. The proportion of potash in the natural water is very small—less than 0.5 per cent of the water and its contained salts—but when this water is concentrated by evaporation, the first salts to crystallize out are those which are nearest saturation in the solution—that is, common salt and sodium sulphate—some of the minor constituents, like potash, tending to remain in solution, and to collect and concentrate in the mother liquor. This general order of crystallization has determined the methods now used to separate the potash from both Salt Lake water and sea water.

Analysis of sample of Great Salt Lake water.

[Collected Oct. 24, 1913, by H. S. Gale. R. K. Bailey, analyst.]

Constituents:		Conventional combinations:	
K	1.66	KCl	3.16
Na	33.17	NaCl	75.91
Ca	.16	$MgCl_2$	10.92
Mg	2.76	Na_2SO_4	9.52
Cl	55.48	$CaSO_4$	.34
SO_4	6.68	$CaCO_3$	.15
CO_3	.09		
	100.00		100.00

Salinity, 20.35.

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UTAH CHEMICAL CO., SALTAIR, UTAH.

The Utah Chemical Co., which is a subsidiary of the Southern Cotton Oil Co., and is allied with the Virginia-Carolina Chemical Co., was organized for the purpose of extracting potash and other by-products from the "mother liquors" that have formerly gone to waste from the salt works of the Inland Crystal Salt Co.

A plant and an auxiliary series of evaporating ponds have been constructed adjacent to the salt-making ponds of the Inland Crystal Salt Co. The potash plant is on the north side of the Saltair railroad, about a mile east of the salt company's station, and is locally known as Potash Siding. Operation here has been somewhat intermittent, but shipments were nevertheless maintained throughout most of the year. The product is a mixed salt carrying from 9 to 15 per cent of potash (K_2O). Some magnesium chloride liquor was also shipped.

The liquor received from the salt company is simply evaporated, at first in open vats similar to those in which the salt is made, and later by artificial heat under cover of the buildings. As received the brine is saturated with respect to both sodium chloride and sodium sulphate and contains about 2.5 to 3 per cent potash (K_2O). A sample of bittern or mother liquor obtained by the writer from the salt vats of the Inland Crystal Salt Co. in the fall of 1912 was analyzed by J. G. Smith at the Cooperative Laboratory at Reno, the analysis showing a content of 35.26 grams of dissolved salts per 100 cubic centimeters, and of 2.73 per cent potash (K_2O) in the dissolved salts, or potash only about 1 per cent of the solution; but this sample was taken after a season of unusually heavy rain, which had prevented the usual concentration.

Partial approximate composition of mother liquor from salt works, Great Salt Lake, Utah.

K_2O	2.50
SO_4	9.25
MgO	6.75
Cl	14.15
	32.65

On evaporation this liquor throws down a crop of crystals consisting mostly of sodium chloride and sodium sulphate, which is discarded, and by this means the potash content of the salts of the remaining liquor is increased to about 4 per cent. An ice-making plant was installed for the purpose of throwing down the sulphate by refrigeration, but it is not known whether this part of the process has worked successfully. The liquor is then taken to the multiple-effect evaporating system, which is fitted with salt traps, in order that the evaporation in the first "effect" shall crystallize and separate as much sodium chloride as possible without large deposition of potassium salts. In the next "effect" a solid mixture of sodium chloride and potassium chloride is thrown down, leaving a mother liquor containing practically all the magnesium chloride with some potassium chloride and, of course, some sodium chloride. The solid mixture, carrying 9 to 12 per cent or more of potash, is dried and sacked for shipment without further refining.

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SALT LAKE CHEMICAL CO., GRANTS, UTAH.

The Salt Lake Chemical Co. is a subsidiary of the Diamond Match Co., organized for the manufacture of potash and possible by-products from the water of Great Salt Lake. The plant is on the north side of the main line of the Western Pacific Railroad about a quarter of a mile east of Grants, a minor station 31 miles west of Salt Lake City. Grants should be distinguished from Grantsville, an older farming, stock-raising, and sheep-ranching settlement of about 1,200 people, 6 miles south. The post office recently established at the Chemical Co.'s office has been named Burmester.

This is one of the three experimental projects started in 1916 by the Diamond Match Co. for extracting potash needed for making the potassium chlorate used in manufacturing matches. The plant is like that of the Utah Chemical Co. in that it uses Salt Lake water, but it differs in that its principal product is to be potash derived direct from the lake water and not as a by-product, although undoubtedly other materials, even common salt, may be produced later if the main object of the project is successfully attained.

The site at Grants seems to afford unusual facilities for handling this brine. Here, at a point about 2 miles from the lake and at an elevation of about 16 feet above the average level of the lake water, there is a series of natural clay-bottomed sloughs, which were readily divided into evaporating ponds. Inclosed as they are by steep clay banks, there is little danger of loss by overflow or leakage, and apparently no great difficulty will be experienced in maintaining dikes. Vats covering about 300 acres were made in the spring of 1916, and work on the plant was started about March 1. The water is taken from a place along the lake shore where it lies over a broad, shallow bottom, in a position that possibly favors a slight preliminary concentration, and after it is exposed in the vats through the season of evaporation it deposits the usual crops of salt and some sodium sulphate, leaving a residual bittern similar to that of the salt works. As care need not be taken to preserve the deposited salt in purified form, the liquor can be concentrated in potash and magnesia somewhat more than the ordinary waste liquors or bitterns of salt works.

The original lake water of average concentration that carries about 20 per cent of salts contains about 0.4 per cent of potash (K_2O), which is equivalent to about 2 per cent of potash (K_2O) in the dry salts. The potash content of the bittern has been increased still more by the elimination of other constituents, as shown by an analysis already quoted (p. 95). The exact degree of further concentration of the potash in the liquor of the vats was not stated by the operators, but as finally drawn to the artificial evaporators it is supposed to carry about 4 per cent, or possibly more. The process employed in handling the liquor apparently consists mainly or entirely of evaporation of the liquor and crystallization of the salts. Potash is undoubtedly the principal product, although magnesium chloride and possibly magnesium sulphate will probably be saved, and some method of utilizing the sodium chloride (common salt) and sodium sulphate may be devised.

When the plant was visited in September, 1916, construction was well under way. The office and chemical laboratory and some dwellings had been built, as well as a tall steel-frame building covered

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with galvanized iron, supposedly to house boilers, vacuum evaporators, and accessory pumps, and north of this building there were wooden storage or crystallizing tanks.

According to an article in the Salt Lake Tribune of November 13, 1916, the officials of the company had then announced that regular operations in refining potash would begin November 15, and that although the plant had been running for some time, no production had yet been attempted, as the equipment had not been complete. The first shipment was, however, made just at the end of 1916. The officials of the company state that although the operation has proved successful the product will probably be unable to compete in price with German muriate of potash when importations from Germany are resumed because of the high cost of production and high freight rates.

SALDURO SALT MARSH, UTAH.

NATURE OF THE DEPOSIT.

An extensive salt field, known as Salduro Salt Marsh, lies directly across the main line of the Western Pacific Railroad 109 to 116 miles west of Salt Lake City. It is said to have been first brought to attention by the engineers who were building the railroad across this part of the desert. At first Salduro was merely one of the sidings or passing tracks which happened to fall near the center of the salt deposit. The whole area of the salt crust was originally staked in salt claims by local people, who organized under the name of the Montello Salt Co., of Ogden, Utah. After several years of unsuccessful attempts to produce salt this company leased the property to the Capell Salt Co., of Salt Lake, which erected a small mill and equipment and for a season or two gathered and ground and shipped salt for domestic use. Recently the project seems to have been merged into or transferred to the potash enterprise of the Solvay Process Co.

The accompanying map shows the location and area of the deposit, which, according to the Land Office plats, covers about 125 square miles. The surface of this deposit closely resembles that of the crystalline salt area at Searles Lake, Cal., consisting of clear white crystalline salt cracked into polygonal blocks. The salt mass at Salduro is much shallower than that at Searles Lake, consisting at a maximum of only 3 to 5 feet of salt, which overlies a soft, wet saline mud of unknown depth. The salt is said to be thickest near the center and to thin gradually toward the edges. This deposit is surrounded at the surface by a zone of soft mud that contains much salt and brine, and this muddy zone gradually merges into the low rolling plain and sand dunes of the Great Salt Lake Desert.

The valley or depression in which this salt field lies is broad and shallow, scarcely noticeable as a basin to one crossing the desert, and the divides between it and Great Salt Lake must be low. During the later receding stages of the ancient Lake Bonneville it may have been a broad shallow arm of the lake, which was finally cut off and has

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never had sufficient tributary water to cause it to overflow. In winter the surface of the salt is covered with water, and evidences of wave action may be seen along the railroad embankments, but in summer the water disappears by evaporation.

Analyses of the crystallized salt of this deposit show that it contains very little potash—about the same as that in the salt of the representative natural salt deposits tabulated on page 83. However, the salt in certain zones contains flows of heavily saturated brines, and similar brines are found at greater depth within the underlying muds and are now supposed to hold most of the potash in the de-

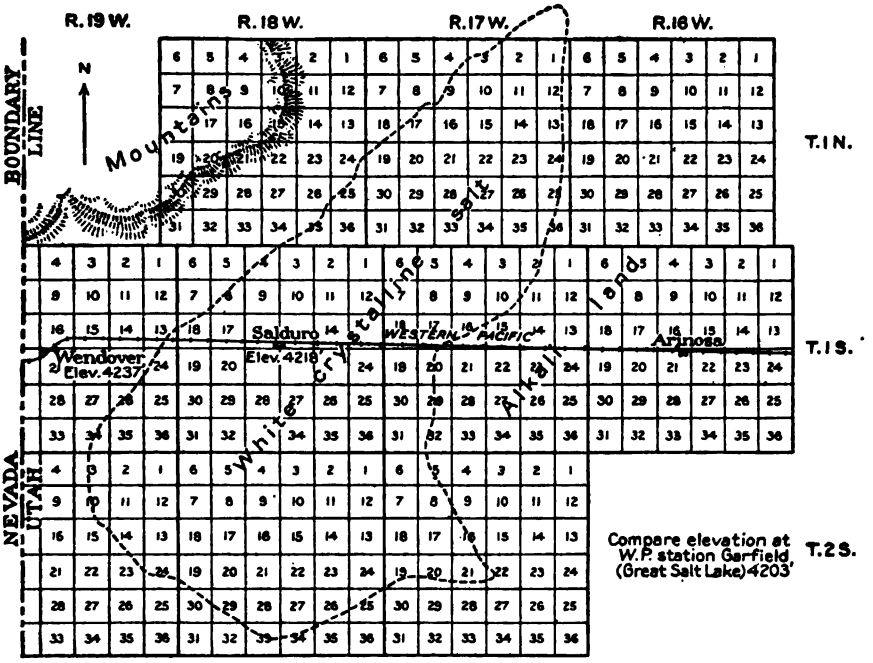

FIGURE 3.—Map of the Salduro salt deposit, Utah.

posit. These brines appear to flow freely and undoubtedly exist in large quantity, although they can hardly be comparable in quantity to the supply found in the much thicker saline deposit at Searles Lake.

The following analyses of samples of brines collected by the writer from the Salduro deposit show that it is of nearly uniform composition, whether taken from the surface salt layers or from the deeper flows. The analyses show that the samples taken from holes that had completely pierced the salt crust are slightly richer in potash but the evidence is insufficient to justify a definite conclusion on this point.

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Analyses of samples of brines from Salduro salt marsh, Utah.

[W. B. Hicks and R. K. Bailey, analysts.]

Constituents.	1	2	3	4	5
K	3.18	4.01	2.85	3.69	3.36
Na	33.78	.....	.....	32.07	.....
Ca	.30	.....	.....	.26	.....
Mg	1.70	.....	.....	2.29	.....
Cl	59.60	.....	.....	59.73	.....
SO_4	1.44	.....	.....	1.96	.....
	100.00	.....	.....	100.00	.....
Ignited residue	26.78	25.68	26.85	27.00	25.54
Specific gravity	1.211	1.206	1.211	1.2124	.....

Total salts (by summation), 27.07 per cent.

1. Sample from hole about 3 feet deep, just penetrating the salt crust, a quarter of a mile due south of the railroad signboard "Salduro." Collected after pumping for about 5 minutes with a small hand pump.
2. Sample from hole about 3 feet deep, just penetrating the salt crust, 1 mile S. 39° E. of hole that furnished sample 1. Collected in same way as sample 1.
3. Sample from hole 37 inches deep, which had not penetrated the salt crust, just back of the old salt camp at Salduro siding.
4. Sample from open trench 3 feet deep, dug in the salt crust near Salduro siding, just north of the Capell salt mill.
5. Sample from the flow within the underlying mud (as nearly as could be ascertained), taken at a depth of about 12 feet in a well whose upper part was cased.

Calculated to the conventional combinations for common salts analysis 4 of the foregoing table may be expressed as follows:

Salts in the Salduro brine.

Sodium chloride (NaCl)	81.04
Potassium chloride (KCl)	7.03
Magnesium chloride ($MgCl_2$)	9.07
Calcium chloride ($CaSO_4$)	0.88
Sodium sulphate (Na_2SO_4)	1.98
	100.00

The distinctive features about this brine as compared with the other potash-bearing brines that have been considered are the low content of sulphate, which is favorable to the separation of the potassium salts and the large content of magnesium salts, which is also considered favorable.

SOLVAY PROCESS CO., SALDURO, UTAH.

After investigating practically every considerable surface saline deposit in the country the Solvay Process Co. decided to erect a plant for extracting potash at the Salduro salt marsh. In the fall of 1916 this company began the construction of a refinery designed to separate potash and doubtless also magnesium chloride and other by-products from the Salduro brine. The brine will be taken from wells and trenches sunk in the salt flat to draw the deeper supplies as well as those near or in the salt. No authentic information is made public as to the detailed plans of this enterprise, but this project may be considered one of the important developments of the coming year.

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POTASH AS A BY-PRODUCT FROM OTHER SALT AND SODA WORKS.

AVAILABLE SOURCES.

About 1860 the systematic extraction of potash from the water of the Mediterranean was begun in southern France, where "a long line of level shore, a tideless sea, a powerful summer sun, and a sufficient degree of cold in winter have all combined as natural advantages to lend success to the processes." This work was apparently continued for some time, as occasional references to it are found in the literature. Thorpe,[1] who gives a summary of the methods used, says that the mother liquors obtained in making sea salt have been fully utilized at Giraud-en-Camargue, at the mouth of the Rhone, originally by Balard and later by Merle and Pechiney. Mendeleeff reports that "summer salts" (magnesium and potassium salts) were being produced on the island of Camargue, near the mouth of the Rhone, as late as 1870.

In brief, the treatment was as follows: After the salt (NaCl) has been obtained from each cubic meter of sea water 64 liters of mother liquor testing 27° B. remains. This liquor is further concentrated by solar heat to 32½° B., and the salt obtained by this concentration being of inferior quality is discarded. Further evaporation, from 32½° to 35° B. separates a mixture of sodium chloride and a nearly equal quantity of magnesium sulphate which is known as "sels mixtes," and which is worked up in various ways, especially for Glauber's salts, by artificial cold. The liquor of 35° B. is kept during the winter in large, deep tanks, where its temperature is prevented from falling below 12° C., so that only Epsom salt and no carnallite crystallizes out. The new mother liquor, testing 33° B., of which there is now 16 liters per cubic meter of the original sea water, is further evaporated by artificial heat until it is concentrated to 37° B., tested hot. This liquor and magnesium chloride, which is a by-product of a later stage of concentration to 40° B., are run together in an iron mixing pan, the magnesium chloride being kept in excess and causing a deposition of mixed salts, which are dredged out of the pan. The hot liquor still contains the potash, which, when the liquor is cooled, separates as carnallite. This is decomposed by agitation with cold water, the potassium chloride remaining as a solid and the magnesium chloride going into solution.

Similar methods of recovering potash are said to have been attempted at one or two places in the United States, though no production of consequence has been reported except from the operations about Great Salt Lake, already described.

The following analyses of some of the waste liquors at salt works show the concentration of potash and soluble magnesia that may be obtained in this way. The relatively small supply of such liquors places a definite limit on the probable production of potash from this source.

[1] Thorpe, Edward, Dictionary of applied chemistry, rev. ed., vol. 4, p. 340, 1913.

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Composition of some bitterns from sea water.

[Samples collected by E. E. Free; analyses by R. F. Gardiner, recalculated by W. B. Hicks.]

Radicles in per cent of anhydrous residue.

	1	2	3	4	5	6	7
K	2.52	4.11	3.89	3.99	5.44	10.04	3.22
Na	24.59	23.27	11.47	7.57	2.30	26.83	16.42
Ca	.37	.68	.18	.14	.25	.06	.30
Mg	7.37	7.18	14.91	17.13	20.09	2.47	11.98
Cl	55.02	54.20	52.87	50.07	55.72	51.72	52.09
SO_4	9.21	9.64	15.80	20.28	15.69	8.31	15.24
Br	.92	.92	.88	.82	.51	.57	.75
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Salinity in grams per liter	325.6	325.8	339.2	366.0	395.1	348.8	366.3

Conventional combinations in per cent of anhydrous residue.

KCl	4.80	7.83	7.40	7.60	10.36	19.08	6.15
NaCl	62.48	59.19	29.09	19.24	5.84	68.65	41.68
$MgCl_2$	20.00	19.60	42.65	46.77	63.35	1.20	32.08
$CaSO_4$	1.23	2.27	.68	.46	.83	.17	1.01
$MgSO_4$	10.44	10.07	19.18	25.00	19.04	10.24	18.21
$MgBr_2$	1.05	1.04	1.00	.93	.58	.66	.87
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

1. Leslie Salt Refining Works, San Mateo, Cal. Representative sample from near northwest corner of mother-liquor pond.
2. Leslie Salt Refining Works, San Mateo, Cal. From southeast corner of mother-liquor pond.
3. Leslie Salt Works, San Mateo, Cal. From salt-making pond in which salt had been "making" during the summer.
4. Oliver Salt Works, Mount Eden, Cal. Mother liquor from slop pond representing five years' accumulation.
5. Oliver Salt Works, Mount Eden, Cal. Mother liquor that had been subjected to some special treatment.
6. California Salt Co., Alvarado, Cal. Mother liquor from "slop" pond representing about three years' accumulation, though considerable quantities had been abstracted for "forcing" and small quantities of other waste liquors had been added.
7. Pioneer Salt Co., San Francisco, Cal. Mother liquor; one year's accumulation.

Some bitterns from the natural brines of Michigan and Ohio have an equally high content of potash, but data are not at hand to show the supply of such materials or whether any of them have been utilized for recovering potash.

WHITNEY CHEMICAL CO., SAN MATEO, CAL.

Production of potash salts and magnesium chloride is reported by the Whitney Chemical Co., at the Leslie Salt Refining Works, San Mateo, Cal. After the sea water is evaporated in ponds to a density of about 30° B., the salt formed is removed and refined by the vacuum process. The remaining liquors are then worked for their salts of potash and magnesia. One of the fertilizer journals reports that epsom salts also have been made, and that the potash is manufactured in two grades, one containing 25 per cent KCl and the other 75 to 85 per cent KCl. This work is said to have been done under the direction of Dr. Carl Elschner.

LONG BEACH, CAL.

It is stated that magnesium sulphate has for some time been recovered from the bitterns of the salt works at Long Beach, Cal., and that potash might also be produced.

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INYO DEVELOPMENT CO., KEELER, CAL.

Dr. Carl Elschner[1] gives an account of the production of potash in 1915 from the "spent liquor" obtained by the Inyo Development Co. by the separation of soda from the waters of Owens Lake, Cal. It is said that the company gave little attention to potash in 1916, however, owing to the increased demand for soda, although liquor suitable for the manufacture of potash at some future time was stored.

NATURAL SODA PRODUCTS CO., KEELER, CAL.

The grant to N. Winkle and W. W. Waterson of a patent for obtaining potassium chloride from saline waters (U. S. patent No. 1184806, May 30, 1916) indicates that the second of the two soda companies at Owens Lake is considering the possibility of producing potash as a by-product of soda manufacture from the water of the lake. This company is concentrating the water by solar heat, carbonating the solution in towers, and using the limestone from a near-by deposit as a material for producing gas. The bicarbonate is separated from the liquor by centrifugal or filter press. The company is reported to be making sodium bicarbonate carrying about 12 per cent moisture. It is proposed by this patent to treat the mother liquor of this process by further evaporation to precipitate first the mineral trona and later sodium chloride and sodium sulphate. Concentration is stopped when potassium chloride begins to deposit and the liquor is cooled to crystallize out potassium chloride.

MOTHER LIQUOR FROM SALT VATS AT HUXLEY, NEV.

A sample of the mother liquor that stands over the salt deposited in the vats of the small salt works at Huxley, Nev., was collected by the writer August 26, 1915, and analyzed by R. K. Bailey. The analysis showed that the liquor contained 31.15 per cent of dissolved constituents, and that 3.53 per cent of the dried residue was potash (K_2O). The by-products that could be recovered by the present small operation would, of course, be insignificant.

MISCELLANEOUS UNDEVELOPED PROJECTS.

Besides the projects that have produced potash from natural salts or saline solutions, or that nearly reached the producing stage in 1916, there have naturally been many others, some of them more or less speculative. All the data that have been gathered as to these projects can not be given here, although a publication of the experience they have gained might prevent a repetition of mistakes or misconceptions as to the kind of materials that may be valuable as a source of potash. Some of the projects here mentioned undoubtedly represent honest endeavor to produce potash commercially and may in the end be successful. Those noted do not include the many reputed discoveries of deposits of nitrates, some of which yielded samples carrying potassium nitrate, but none of which appear to be of commercial value.

[1] Min. and Sci. Press, Jan. 29, 1916, pp. 155–156.

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MICHIGAN.

Attention is again directed to the possibility of discovering potash in the natural salts or brines of certain developed deposits in Michigan. A. W. Grabau,[1] of the Michigan Geological Survey, has concluded that the Salina, or middle Silurian, which bears the rock salt in that State, may contain beds of potash. Several thousand square miles of southeastern Michigan, from St. Clair to Monroe County, and western Ontario are underlain by large deposits of rock salt. In the Detroit-St. Clair River area these beds have an average aggregate thickness of nearly 400 feet. The thickest bed occurs near the bottom of the series. The depth of this bed at Oakwood, a suburb of West Detroit, is 1,437 feet and at Wyandotte about 1,100 feet. Dr. Grabau expresses the opinion, based on his interpretation of Silurian history, that the "lowest salt beds under Detroit ought to carry potash salts similar to those found at Stassfurt, the geologic history being the same." This statement, he says, holds good only for the lowest bed.

TEXAS.

Explorations based on reasoning similar to that of Dr. Grabau have been made by the United States Geological Survey in northwestern Texas and adjacent territory. Field geological studies have been made by N. H. Darton on the "red beds" in Texas and New Mexico, with special reference to the salines they contain; and the Survey is now boring a well at Cliffside, Potter County, Tex., in order to determine whether the salt deposits there contain potash. Further reference is made to this work on page 165.

NEW MEXICO.

A well is being drilled near Carlsbad, N. Mex., under private auspices to test the salt beds in that region for potash in much the same way as at the Geological Survey's well at Cliffside, Tex. Former drilling near Carlsbad has shown that an unusually thick series of salt strata underlies the place. A record of one of the borings, known as the Vineyard well, drilled several years ago in search of water, shows a continuous section of solid rock salt 250 feet thick at a depth of 500 to 750 feet. The report is that at a depth of about 545 to 550 feet in the old well, near the top of the thick salt bed, a sample was taken which when analyzed proved to contain about 5 per cent of potash. The new boring is intended to test this deposit and to ascertain whether it contains potash in commercial quantities. The well will be drilled with churn tools until the salt is reached, when it is planned to employ a special bit and drill the hole deeper without water, if possible, compressed air to be used to blow out the cuttings. This work will be watched with interest.

ARKANSAS.

A Colorado company is said to have procured a lease on several hundred acres of land 2 miles northwest of Heber Springs, Ark., at what was designated as the Locowana potash mine. The company claims to have found water-soluble potash, some of it in the form of alum, which was reported as being tested on a considerable scale in Denver. The results of this test are not available.

[1] Mineral resources of Michigan: Michigan Geol. and Biol. Survey Pub. 19, Geol. ser. 16, pp. 325–327, 1915.

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COLORADO.

Among the numerous reported discoveries of potash deposits in Colorado that in the San Luis Valley doubtless deserves mention. Early in the season a report was received that soda was being shipped from a deposit near the San Luis Lake to Denver to be worked for potash. Inquiry showed that the soda was being shipped as soda only and only in an experimental way. Analyses of some of this soda and of the associated brine collected during the summer of 1916 by E. S. Larsen, of the United States Geological Survey, have shown the following results:

Soluble constituents in brines and salt from San Luis Valley, Colo.

[W. B. Hicks, analyst.]

	Soda Lake brine.		Salt at bottom of Soda Lake.		Brine from lake east of Soda Lake.	
	Percentage of sample.	Percentage of solids.	Percentage of sample.	Percentage of solids.	Percentage of sample.	Percentage of solids.
K	4.49	14.94	2.37	4.73	0.47	10.12
K_2O equivalent to K	5.41	17.98	2.86	5.71	.57	12.22
CO_3	12.67	42.15	19.30	38.56	1.92	41.28
CO_2 equivalent to CO_3	9.29	30.90	14.15	28.28	1.41	30.22
HCO_3	1.51	5.02	14.43	28.82	.57	12.26
Cl	1.24	4.12	.35	.70	.20	4.30
Solids at 180° C	30.05	.....	50.04	.....	4.65	.....

The percentage of potash in the Soda Lake brine is rather large, but as the lake is small, probably not much more than an acre in area, and is only a foot or two deep, and as the supply of concentrated liquor is correspondingly small, it seems unlikely that it can have a very considerable value as a source of potash.

An analysis of the water of San Luis Lake by W. P. Headden showed a content of 9.3 per cent potash (K_2O) in the total dissolved salts, but this water is comparatively dilute, carrying only 798 parts per million of dissolved constituents, so that it could probably not be turned to practical account.

WYOMING.

Several potash projects have been reported from Wyoming to work saline deposits in different parts of the State. Most of these projects seem to have been based on errors of interpretation of analytical results or on inadequate evidence. This statement refers to the saline deposits only, as the Leucite Hills projects are considered in another place.

UTAH.

General conditions.—Utah not only contains the larger operations described elsewhere, but has had its full share of announcements of all sorts of supposed discoveries of deposits containing potash based on small showings of potash in samples of brines or waters and particularly in muds from some of the "dry lakes" in the State. The

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apparent success of some of the potash enterprises near Great Salt Lake and the publicity given to the production from Marysvale have no doubt stimulated this activity. Interest has also been taken in tests of insignificant saline incrustations on rocks in ledges or cliffs, either of nitrates or other salts, such as alum and simple sulphates. The prospectors of such incrustations generally fail to consider the wide distribution of potash in small quantities in soluble as well as insoluble form and are disposed to reason that a small showing on the surface indicates a larger quantity at depth—a miner's axiom that certainly does not apply to most surface indications of potash.

In order to enter the market in competition with the foreign product soluble domestic potash salts must be obtainable cheaply and in very large quantities. It is, of course, impossible to say from what source potassium salts may soon be recovered, either as by-products of established industries or otherwise, but there is certainly no justification for encouraging the prospector to search the hills for small saline incrustations that may on analysis show some potash or to estimate the value of potash in muds or clays that contain only a little more potash than the average earth's crust as a whole.

Iron County.—Since 1914 reports have appeared concerning potash in Little Salt Lake, in T. 33 S., R. 9 W., near the towns of Parowan and Paragonah, Utah. This lake is described as a shallow body of saline water that is normally about 3½ miles long, less than a mile wide, and about 1½ feet deep. It lies in the center of a mud flat that measures about 12 miles from north to south. The basin is without outlet, and the water therefore varies in quantity and in concentration from season to season, analyses showing a range of 10 to 27 per cent of dissolved salts. The potash (K_2O) in the dissolved salts of this water is said to range from less than 2 to 4.22 per cent, and analyses of the muds show a saline content similar to that of the water.

Early in 1916 the attention of potash prospectors in Iron County seems to have shifted to supposed deposits in rock form, which are described as lying in the hills east of Parowan and Paragonah.[1] Here strata of white saline sandstone that lie between beds of quartzite and conglomerate were supposed for a time to carry potash. Tests of specimens of the sandstone, however, showed that they contain only a small percentage of soluble matter, chiefly aluminum sulphate, and some sulphate of iron, but only a negligible amount of potash.

Quitchipa Lake, a few miles west of Cedar City in the same general vicinity, has also been exploited for potash. Its water is reported to have contained about 3 per cent of dissolved salts, less than 1 per cent of the dried residue being potash.

Millard County.—Late in 1916 several projects were reported from Millard County. The muds and waters of Tule Lake, or Tule Flat, near the House Range, or the part of it that is locally known as the Antelope Mountains, are said to have been sampled and tested, and for a time considerable enthusiasm was raised over what was actually only a normal percentage of potash. The last reports state that it is proposed to use as fertilizers muds carrying 2.3 per cent potash, only a small part of which was available or readily soluble in water.

[1] Salt Lake Min. Rev., May 30, 1916; Eng. and Min. Jour., June 3, 1916, p. 1004.

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There is a small salt plant, including evaporating vats, at the Hawley Salt Marsh, in eastern Millard County. Water usually stands 18 inches to 2 feet deep over a part of this marsh, sometimes being concentrated to saturation with common salt. Tests of this brine are reported to show 3 to 4 per cent potash in the dried residue, but other determinations are quoted showing 2 per cent or less. Black mud 18 inches to 2 feet thick, containing much organic matter, forms the surface over a considerable area. This mud and the water derived from it have been tested with the usual results. A layer of gypsum is said to be found below the mud.

Box Elder County.—In July, 1916, a discovery of potash in Box Elder County, Utah, about 20 miles south of Oakley, was announced in the press.[1] The deposit was described as a ledge showing an efflorescence of alum and potash. No later reports have been obtained, and it is likely that the first announcement as to extent of the deposit or its content of potash may not have been substantiated by further investigation.

NEVADA.

Early in 1916 a considerable exploration was made of the alum deposits near Blair and Silver Peak, Nev. These deposits are said to be half a mile from the Blair Railroad and 11 miles from Blair Junction. They have been known for many years and have been covered by mining claims, but no attempt has hitherto been made to work them. The work recently done consisted of sinking a shaft and of running several crosscuts in an effort to block out a deposit sufficient to pay for mining and preparing the alum for market. The prospectors, however, after going into the matter thoroughly abandoned the project as impracticable even with potash at its present abnormally high price. Some beautiful specimens of clear crystalline potash alum and of alum and sulphur were obtained in the work. The deposit is evidently a fumarole product—that is, it is a result of gaseous emanations that accompanied late volcanic activity in this region.

OREGON.

The proposal to develop the potash and soda resources of two large lakes in southern Oregon, Abert and Summer lakes, in Lake County, has been before the public for some time. As reported early in 1916, a lease was given by the State of Oregon to certain individuals for extracting from the waters of these lakes their content of soda and potash. This project as reported included a 270-mile pipe line to Columbia River and a large hydroelectric plant, and involved an investment of about $7,000,000.

According to the available analyses the waters of these lakes carry alkaline salts in rather dilute solution, that of Abert Lake ranging from about 3 to 8 per cent, and that of Summer Lake from about 2 to 4 per cent. Although these waters undoubtedly contain a very large quantity of alkaline salt they are only about as concentrated as ordinary sea water, and the quantity of potash they contain is only slightly greater than that in sea water. Therefore soda might be recovered from them by solar evaporation, much as salt is now re-

[1] Walla Walla (Wash.) Bulletin, July 28, 1916.

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covered from sea water, and potash might also be recoverable as a by-product. The lakes are remote from routes of transportation.

Although no direct report of progress on this enterprise has been made, financial backing has doubtless been obtained for it, as the holding of the lease from the State is said to involve substantial deposits to guarantee the good faith of its promoters.

CALIFORNIA.

Most of the California saline deposits have already been described and many of them have been tested to show their content of potash, but with a few exceptions, like Searles Lake and Owens Lake, they do not now appear to be likely sources of commercial potash. Samples from Cane Lake, Roderiquez Dry Lake, and the sulphate deposits at the south end of Roderiquez Lake, the basins known as Cadiz, Bristol, and Amboy lakes, several deposits in the Salton Basin, Panamint Valley, Saline Valley, Eureka Valley, Death Valley, and other places have been tested, mostly without unusual results.

Death Valley has been of considerable interest as a source of potash. Some boring and testing for potash was done in the bottom of Death Valley by the Geological Survey in the winter of 1912–13.[1] Later several wells about 1,000 feet deep were drilled in the valley by private interests. This work has shown that an immensely thick deposit of salt (mainly sodium chloride) underlies this valley; but, though the salts and brines of this deposit contain a small proportion of potash, it has not been shown that it can be profitably recovered, and certainly none of the projects for recovering it seems to have progressed very far. An average of 14 analyses of brine from the central salt deposit in Death Valley shows 0.59 per cent potash (K_2O). These brines were all saturated mainly with common salt, and though potash is being extracted from the water of Great Salt Lake, which has a slightly lower content of potash, there are reasons why Great Salt Lake might be preferred to Death Valley as a source of brine for making potash. It is difficult or impossible, however, to say exactly what factors will finally determine the sources of brine for this use. Death Valley contains one of the largest salt deposits in the western desert basins. Other valleys contain smaller deposits, more or less similar, but none of them seems to offer special advantages for the extraction of the small percentage of potash from the salts they contain.

PRODUCTION OF POTASH FROM ALUNITE.

NATURE OF THE DEPOSITS.

Alunite, a mineral containing potassium, is found at many places and is now known to be much more common than was formerly supposed. In general it seems to be a product of the alteration of feldspathic rocks. Most alunite is disseminated through porphyritic volcanic rocks in proportions so small that it can not be profitably extracted. In this country it has been found in form so massive and so pure as to make it available as a source of potash only in the deposits

[1] Gale, H. S., Prospecting for potash in Death Valley, Cal.: U. S. Geol. Survey Bull. 540, pp. 407–415, 1914.

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at Marysvale, Utah. Other workable deposits may be found, but none have yet been actually developed.

A list of publications on alunite and on methods of utilizing it is given on page 116.

ALUNITE NEAR MARYSVALE, UTAH.

PRODUCTION.

Potash was first produced from alunite at Marysvale, Utah, in September and October, 1915, from the Gillan-Custer claims, on Little Cottonwood Creek. Production was maintained during 1916 except for two months at the end of the year, after the mine equipment had been destroyed by fire.

DEVELOPMENT.

In 1916 many attemps were made to exploit other deposits of alunite, not only in the immediate vicinity of the deposit already exploited, but throughout a considerable district about Marysvale. Some of these attempts have been described in a report already published[1] and others have since been made. It is difficult to keep fully informed as to all the newer deposits or properties, some of which may prove to be of practical value, but there is at least one principal vein system or zone of alunite in the Marysvale district, the one now mined, which lies chiefly along the crest of the ridge between the main branch and the North Fork of the Little Cottonwood. The value of the many adjoining or more distant properties has not yet been entirely proved.

For practical purposes the alunite of the Marysvale district may be distinguished as of two kinds. One, presumably the more valuable, is the purer massive vein material, which was originally found on Little Cottonwood Creek and which occurs there in considerable quantity. The other is like that in the more common occurrences of alunite, in which the mineral is disseminated in less distinctly crystalline form through rocks that contain much silica and other materials and that are consequently less valuable sources of alunite. Small veins of purer alunite are found here and there in the disseminated deposits, but the quantity available is not readily evident. It is possible that other deposits in the Marysvale district than those first discovered may be commercially valuable, but much that is open to serious question has been said concerning those other deposits. Certainly the mere existence of alunite anywhere is no proof that it occurs in deposits of large extent or value, although doubtless most of its occurrences deserve careful investigation.

COMPOSITION.

Alunite is a hydrous sulphate of aluminum and potassium ($K_2O.3Al_2O_3.4SO_3.6H_2O$), a crystalline mineral that is insoluble or only very slightly soluble in water. It occurs in coarsely crystalline form at Marysvale, where it was at first mistaken for feldspar or calcite, and at Marysvale and elsewhere also in finer crystalline masses and

[1] Loughlin, G. F., Recent alunite developments near Marysvale and Beaver, Utah: U. S. Geol. Survey Bull. 620, pp. 237–270, 1916.

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in a soft powder resembling kaolinite. It is concentrated in veins or vein zones, and is also disseminated through zones in porphyry, where the general shattering and alteration of the country rock indicates that it has been produced or introduced by common vein-forming agencies.

The following analyses of selected specimens of the Marysvale alunite represent two types of the mineral collected by the writer from the Gillan-Custer claims. The theoretical composition of pure alunite as stated by Dana is given for comparison. The general run of the alunite mined at Marysvale is not so pure as these selected specimens, as it includes more foreign material and vein wall rock, which increase the content of silica and correspondingly lower the proportion of potash. The alunite in the run-of-mine material delivered at the mill for crushing is supposed to average somewhat less than 9 per cent K_2O.

Composition of selected specimens of alunite from the region near Marysvale, Utah, compared with composition of theoretically pure alunite.

	Marysvale alunite.		Theoretical composition (Dana).		Marysvale alunite.		Theoretical composition (Dana).
	1	2			1	2	
Al_2O_3	37.18	34.40	37.0	H_2O+	12.90	13.08	13.0
Fe_2O_3	Trace.	Trace.	.....	H_2O-	.09	.11	.....
SO_3	38.34	36.54	38.6	SiO_2	.22	5.28	.....
P_2O_5	.58	.50	.....				
K_2O	10.46	9.71	11.4		100.10	100.18	100.0
Na_2O	.33	.56	.....				

MINERAL PRODUCTS CORPORATION.

The principal operator on the alunite in the Marysvale district is the Mineral Products Corporation, which built the first mill and furnace for treating it and took over the Gillan-Custer group of claims, on which the mineral was originally discovered. These claims are in the high mountains about 5 to 6 miles directly southwest of Marysvale and are generally reached by the road up Little Cottonwood Canyon. The deposit covered by these claims is now being developed by regular mining methods, and it is said at least 200,000 tons of high-grade alunite had been blocked out at the close of 1916. The writer's original estimate[1] that the deposit contains 300,000 short tons for each 100 feet of depth, so far as the vein maintains its surface dimensions and quality, therefore appears to have been moderate, for it broadly accords with the facts disclosed, although the exact depth to which the mass blocked out may extend is not stated.

The mine was not visited in 1916 by any member of the United States Geological Survey. Owing to fire, it was shut down from November 1 to the end of 1916, but was again in full operation soon afterwards. The alunite is still delivered by an aerial tram, a little over a mile in length, to wagons in Little Cottonwood Canyon, from which it is hauled about 3½ miles to the mill. The mill is described

[1] Butler, B. S., and Gale, H. S., Alunite—a newly discovered deposit near Marysvale, Utah: U. S. Geol. Survey Bull. 511, p. 12, 1912.

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in the report[1] on potash salts for 1915, but dust collectors, gas coolers, and other appliances have been added to prevent loss of potash in the form of dust and vapor. Nothing appears to have been done to utilize the alumina that remains after the potash is leached from the roasted alunite. It is accumulating at the mill and will be available for use later if practicable.

The Mineral Products Corporation's mill is about 5 miles southwest of Marysvale. It stands just below the mouth of the gorge by which Little Cottonwood Creek leaves the mountains, at the upper edge of the bench on the west side of Sevier River, about 2 miles from the river.

FLORENCE MINING & MILLING CO.

The upper (northern) extension of the veins or vein zone of the Gillan-Custer group has been covered by a group of old mining locations controlled by the Florence Mining & Milling Co., of Philadelphia. Deposits of vein alunite of quality similar to that on the property now being worked occur on these upper claims and could doubtless be exploited in much the same way as those on the Gillan-Custer property, though they are less accessible by ordinary wagon route. Estimates of the quantity of alunite in the richer veins of this upper group made by Loughlin[2] indicate that at least as much alunite is represented at the surface as on the Gillan claims, but it remains to be seen whether the deposits extend to the same depth.

Many projects have been formed to work these deposits. In the fall of 1915 the Utah Potash Co., financed largely by Los Angeles capitalists, was organized to mine the alunite and to treat it in a mill to be erected near Marysvale. Some experimental work on the alunite was done at the plant of the American Keene Cement Co., at Sigurd, Utah, near Richfield, about 36 miles north of Marysvale, on the same branch railroad. Later this company obtained alunite for its experiments from a deposit near Belknap Siding, about 5 miles north of Marysvale.

In 1916 the Florence Mining & Milling Co. made a contract to deliver calcined alunite for its content of potash, without attempting, for a time at least, to extract or refine the potash salts, and built a new mill and calcining furnace on the river flat about half a mile south of the railroad station at Marysvale, at the foot of the bluff marking the lower edge of the bench or mesa that lies between the mountains and Sevier River. No provision has yet been made for getting the alunite down to the mill except by wagons or trucks and no output had been made at this plant at the end of 1916.

MISCELLANEOUS DEVELOPMENTS OF ALUNITE IN THE MARYSVALE DISTRICT.

The claims that have probably attracted the most attention, except those on Little Cottonwood Creek, are the reported alunite properties along Sevier River, a few miles below or north of Marysvale, particularly those near Belknap siding, in the canyon of Sevier River about 5 miles north of Marysvale station. After the Utah Potash Co. had shifted its operations from the ground of the Florence Mining &

[1] U. S. Geol. Survey Mineral Resources, 1915, pt. 2, pp. 110–111, 1917.
[2] Loughlin, G. F., Recent alunite developments near Marysvale and Beaver, Utah: U. S. Geol. Survey Bull. 620, p. 257, 1916.

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Milling Co., it made some agreement with the owners of claims near Belknap and also near the Krotki iron mine.[1] From January to March, inclusive, about 1,500 short tons of rock was shipped from Belknap to Sigurd, where some of it was experimentally treated at the American Keene Cement Co.'s plant. A single shipment of potassium sulphate, of unspecified quality, and several carloads of ground roasted alunite are reported to have been made before the operations of the company were finally suspended.

In March, 1916, 40 tons of alunite-bearing rock was shipped from deposits near Belknap to a cement plant at Salt Lake. This was roasted under contract by the cement company, the intention being to ship the calcined alunite for use as a potash fertilizer. The material was found to carry only about 2.5 per cent potash and the product after calcining was not of marketable grade, so that the project was considered a failure.

Crystalline alunite of good quality is reported to have been found on the ground known as the Chrystal mine, on the south side of Little Cottonwood Creek. This is in the valley about opposite the Gillan-Custer group.

Tom Gillan's claims in the foothills 3 miles southwest of Marysvale,[2] three-fourths of a mile east of the Deer Trail mine, are said to have been developed by shafts and tunnels and to have showings of promise, but no definite information has been obtained as to what has been found there. These claims are near the mill of the Mineral Products Corporation.

Mr. Gillan reports that large bodies of alunite were discovered early in 1916 on the east side of Sevier River, northwest of Marysvale Peak. Some work was done on this property with unknown results. Another property is said to be on the southwest side of Marysvale Peak, where the alunite is reported to occur in a soft porphyry. It is stated that a branch railroad to this deposit is projected.

Advertisements in the newspapers in October, 1916, offered stock in the Pittsburgh-Utah Potash Co., of Pittsburgh, stating that there is an inexhaustible supply of potash rock in their mines near Marysvale, Utah. The property claimed by this company is said to consist of 348 to 380 acres on Pine Creek near Sevier River, 4 miles northwest from Marysvale. It is announced that the alunite will be put through a crusher and rolls, mixed with powdered slack coal and fed into a rotary kiln from which the roasted material will be passed to a digester; that the potassium sulphate will be dissolved and the solution filtered and evaporated in vacuum apparatus, the crystallized salt to be dried and ground for shipment. No examination of these alunite claims has yet been made by the United States Geological Survey.

Stock is also offered for sale by the Utah Potash Co., incorporated under the laws of Arizona on a capitalization of $1,500,000, based on the ownership of a deposit of alunite rock, described as "practically inexhaustible," in Piute County, 7 miles east of Marysvale, at an altitude of about 10,000 feet. This company announces the use of a new process for treating alunite directly with nitric acid, in a way that involves no evolution of acid fumes, such as are formed in the

[1] Loughlin, G. F., op. cit., p. 253. [2] Idem, p. 252.

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calcination process, all the potash being obtained directly as potassium nitrate (saltpeter). The alumina in the alunite is said to be thus recovered in a high state of purity, and finally, if the saltpeter is converted to other salts of potash, the nitric acid is almost completely recovered. The company's plant is to be built at Trenton, N. J., where there is said to be a large demand for potash in the local industries.

The Potash Co. of Utah (Marysvale), organized to develop alunite claims adjoining those of the Mineral Products Corporation, is also announced, with a capitalization of $1,500,000.

The Potash Products Co., a Delaware corporation, is also reported as claiming properties near Marysvale, but no definite data are given as to its activities.

ALUNITE IN NEVADA.

A project was announced[1] for utilizing the alunite in the ores at Goldfield, but later reports state that it was given up as not feasible, the alunite in ores that might be selected or in the mill tailings carrying too low a percentage of potash to permit its profitable recovery. Investigation has shown that alunite is a prominent ingredient of some of the volcanic rocks about Goldfield, particularly of the country rock about Preble Mountain, south of the town, and near Cuprite, but analyses have shown that this alunite is of the soda-bearing variety.

Other deposits of alunite previously reported from Nevada include those in the Bovard district,[2] at Cuprite,[3] and near Cactus Peak (unconfirmed report). A deposit 22 miles southeast of Las Vegas has been examined by the writer, but although alunite occurs there in considerable quantity its average grade is low and it offers little promise of commercial value. Analysis of a carefully averaged sample taken at what seemed to be one of the most favorable localities gave only 2.20 per cent of K_2O, and other possibly less representative samples gave percentages only a little higher.

The alunite at most of these properties is not the variety that contains much potash or it is widely disseminated in small quantities. It appears to be of little practical value as a source of potash.

ALUNITE IN CALIFORNIA.

Recent reports state that alunite has been discovered in Forest County, Cal., and that analyses made by private parties show that it contains 4.5 to 6.1 per cent of potash.

Specimens of alunite collected in the summer of 1916 by J. S. Diller from the vicinity of Lassen Peak were examined in the laboratory of the United States Geological Survey and found to be about 80 per cent pure, but this percentage was determined by comparing the relative loss on ignition with that of pure alunite and is therefore only roughly approximate. The specimens tested contained 4.94 per cent of potash (K_2O), a percentage so low as to indicate that a part of it consisted of soda alunite. The material is the

[1] Am. Fertilizer, Jan. 8, 1916.
[2] Schrader, F. C., U. S. Geol. Survey Bull. 540, pp. 351–356, 1914.
[3] Phalen, W. C., Potash salts: U. S. Geol. Survey Mineral Resources, 1915, pt. 2, p. 112, 1917.

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white powdery form of the mineral and according to Mr. Diller it is now forming through the action of volcanic gases emanating near this recently active volcano. The specimens came from Supan's sulphur works, 6 or 7 miles north of the town of Mineral, at a point near the southern boundary of the Lassen Volcanic National Park. The ground was first located and prospected as a sulphur deposit and later for natural paint. The country rock is the andesite that forms the old crater of Mount Lassen. Volcanic gases are depositing sulphur in beautiful crystals, as well as other minerals, and are forming alunite by deposition or by reaction with the country rock. No estimate has been made of the quantity of alunite available, but it appears to occur in considerable amount here and possibly elsewhere in the Lassen Peak region.

Samples of alunite that were said to come from the Funeral Range, near Death Valley, Cal., have been sent to the Geological Survey. Specimens of sodium-potassium alunite (natroalunite), sent to the National Museum, are said to have come from a prospect pit in the Funeral Range. They contain impurities and a relatively small proportion of potash. They have been described by Wherry.[1]

ALUNITE IN ARIZONA.

Several reports concerning deposits of alunite in Arizona, in addition to those noted by Schrader,[2] have been received by the Geological Survey, but none of them has yet been substantially confirmed and none of these deposits have been examined by members of the Survey.

ALUNITE IN COLORADO.

Alunite has been reported to occur at several places in Colorado. Certain rocks in some parts of the State have been extensively alunitized, though most of the deposits seem to be of the disseminated type, in which the alunite is mixed with much country rock and carries considerable proportions of the soda variety, natroalunite, so that it is of doubtful value as a source of either alum or potash. Larsen[3] has described some deposits of this type and has furnished the following notes based on recent observations:

Alunitization is a common type of alteration in the mining districts and about the intrusive bodies in the San Juan Mountains. The alunitized rock forms great mountains and at some places covers areas of a square mile or more. The alunitized rock consists chiefly of quartz and alunite, the quartz at many places composing perhaps a third of the rock. However, this rock seldom carries over 4 per cent of potash (K_2O) and probably most of it would run nearer 3 per cent. No veins of pure crystalline alunite such as that found at Marysvale, Utah, have been observed in the alunitized area of the San Juan Mountains, though this ought to be a favorable place to prospect for veins of alunite. Some large bodies of alunite are found in the San Cristobal quadrangle, and others occur near the mining camps of Summitville, Platoro, Spencer, Jasper, and Bonanza, about the old camp of Embargo (northwest of Del Norte), near the old camp of Summer Coon (about 7 miles north of Del Norte), near

[1] Wherry, E. T., Notes on alunite: U. S. Nat. Mus. Proc., vol. 51, pp. 81–88, 1916.
[2] Schrader, F. C., Alunite in granite porphyry near Patagonia, Ariz.: U. S. Geol. Survey Bull. 540, pp. 347–350, 1914.
[3] Larsen, E. S., Alunite in the San Cristobal quadrangle, Colo.: U. S. Geol. Survey Bull. 530, pp. 179–183, 1913.

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Beidell camp (south of Saguache), in the basin at the head of Tracy Creek (also south of Saguache), and in upper Indian Creek above Gateway, on the Lake City Branch of the Denver & Rio Grande Railroad.

Large deposits of alunite-bearing rock are reported to occur near Pintado Peak, in Rio Grande County, and private investigations have confirmed the report, but the potash content of the rock is not sufficiently high to make it a promising source of alum or potash. Some of the rock was examined at the United States Geological Survey and proved to be chiefly an alunitized porphyry, which was in places composed of fairly pure alunite, but for the most part retained the porphyritic character of the original rock. A faded porphyritic texture indicates that the specimens seen still contain most of their original silica and other impurities, and that only a small part is alunite, which occurs in a much disseminated form. Some specimens seem to be of better grade, but most of the larger pieces probably do not carry more than 4 or 4.5 per cent of potash. The deposit was not seen by the writer, and an examination of it might require a change in this preliminary estimate, which is based only on an inspection of samples of the rock.

Other deposits are reported to occur near Westcliffe, Custer County, and are said to carry 6 to 7 per cent potash.

ALUNITE IN TEXAS.

A phosphate-bearing alunite from Gonzales County, Tex., has been described by Wherry.[1] Specimens of the mineral were submitted to the National Museum, but nothing is said as to the quantity available.

A sample of supposed bauxite recently submitted to the United States Geological Survey is said to have been obtained from the bottom of an excavation 11 feet deep, in section 13, block 70, 9 miles northwest of Toyah, Reeves County, Tex., a region where there is considerable evidence of the former existence of hot springs. On examination the sample proved to be hydrous potassium aluminum sulphate very closely related to if not identical with alunite, possibly a metacolloidal form, which is changing into alunite. It contained a little silica and magnesium.

As the material appeared to be of somewhat unusual character, W. B. Hicks has made a careful study of the specimen, and the occurrence itself deserves investigation.

Analysis of sample of alunite from Reeves County, Tex.

	1	2		1	2
K_2O	4.54	6.30	H_2O (above 110° C., by difference)	12.11	16.81
Na_2O	2.01	2.79	H_2O (below 110° C.)	27.96	.....
Al_2O_3	23.90	33.16		100.00	.....
SO_3	23.70	22.90			
SiO_2	5.79	8.04			

1. Percentages determined.
2. Recalculated, with water driven off below 110° C. excluded.

[1] Wherry, E. T., Notes on alunite: U. S. Nat. Mus. Proc., vol. 51, pp. 81–88, 1916.

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ALUNITE IN BRITISH COLUMBIA.

Deposits of alunite-bearing rock are reported to occur on Vancouver Island and are described by C. H. Clapp.[1] This alunite rock, however, carries a large amount of silica—much of it in the form of quartz—and the alunite is the sodic alunite, properly called natroalunite, so that its potash content is rather low, and, according to the data at present in hand, it is not considered a promising source of alum or potash salts.

Analyses of Vancouver alunite.[a]

	1	2	3		1	2	3
Silica	52.00	55.65	44.40	Potash	5.60	4.30	4.50
Alumina	19.95	16.30	21.80	Water	4.40	6.50	7.20
Sulphuric acid	16.00	15.10	21.40				
Oxide of iron	2.05	2.15	.70		100.00	100.00	100.00

[a] Am. Fertilizer, vol. 44, No. 13, p. 54, June 24, 1916.

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1889. Cross, Whitman, On alunite and diaspore from the Rosita Hills, Colo.: Am. Jour. Sci., 3d ser., vol. 41, pp. 466–475.
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1904. Spurr, J. E., Alum deposits near Silver Peak, Nev.: U. S. Geol. Survey Bull. 225, pp. 501–502.
1907. Hayes, C. W., The Gila River alum deposits: U. S. Geol. Survey Bull. 315, pp. 215–223.
1912. Butler, B. S., and Gale, H. S., Alunite, a newly discovered deposit near Marysvale, Utah: U. S. Geol. Survey Bull. 511.
Waggaman, W. H., Alunite as a source of potash: U. S. Dept. Agr. Circ. 70.
1913. Larsen, E. S., jr., Alunite in the San Cristobal quadrangle, Colo.: U. S. Geol. Survey Bull. 530, pp. 179–183.
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1915. Clapp, C. H., Alunite, Kyugnot Sound, British Columbia: Econ. Geology, vol. 10, No. 1, pp. 70–88.
Knopf, Adolph, Some cinnabar deposits in western Nevada: U. S. Geol. Survey Bull. 620, pp. 59–68.
Loughlin, G. F., Recent alunite developments near Marysvale and Beaver, Utah: U. S. Geol. Survey Bull. 620, pp. 237–270.
1916. Norton, T. H., A new deposit of alunite: Am. Fertilizer, vol. 44, p. 54, June 24. Describes alunite on Vancouver Island, British Columbia, and gives analyses.
Wherry, E. T., Notes on alunite, etc.: U. S. Nat. Mus. Proc., vol. 51, pp. 81–88.
Waggaman, W. H., and Cullen, J. A., The recovery of potash from alunite: U. S. Dept. Agr. Bur. Soils Bull. 415, 14 pp.

[1] Clapp, C. H., Alunite, Kyugnot Sound, British Columbia: Econ. Geology, vol. 10, No. 1, pp. 70–88, 1915.

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PROCESSES OF TREATING ALUNITE.[1]

Six or seven processes have been patented for recovering the soluble potash salts from alunite, three or possibly four of which have been practically tested. These are the Chappell, the Morgan, the Cameron, and the MacDowell processes. Dr. Cameron expresses the view that under normal trade conditions potash can be profitably produced from alunite only by marketing the alumina in some form, so as to pay part of the cost of production.

CHAPPELL PROCESS.

The Mineral Products Corporation, the pioneer company in Utah in reducing alunite to soluble potash salts, is using the Chappell process. The ore is crushed so that its coarser fragments are about the size of large peas and is then slowly passed through a rotary kiln in which the temperature is maintained at about 750° C. The roasted alunite is digested with boiling water for several hours and is then filtered through Kelly presses. The cake, which is mainly alumina, is now stored for possible later use. The filtrate is placed in a modern multiple-effect evaporator, and potassium sulphate of about 95 per cent purity, which is practically free of chlorine, is recovered from it by crystallization. The ore now being treated averages about 8 to 9 per cent K_2O, and the alumina residue is said to carry less than 2 per cent potash, so that perhaps somewhat less than 7 per cent of the ore treated is recovered as K_2O.

MORGAN PROCESS.

By the Morgan process finely ground alunite is mixed with one-fourth its weight of lime and roasted at about 1,000° C., preferably in a rotary furnace of the type commonly used in cement manufacture. The lime is used chiefly to prevent the escape of objectionable fumes of sulphur, as practically all the sulphur in the alunite combines with the lime to form gypsum or anhydrite. The roasted mixture is leached in a series of vats where it is heated and agitated by steam so as to obtain hot saturated solutions, which on cooling yield crystallized potassium sulphate. The solid residue from the leaching appears to be mainly a mixture of gypsum and alumina, for which several methods of utilization have been proposed.

CAMERON PROCESS.

By the Cameron process alunite is roasted at a moderate temperature (550° to 750° C.) and the roast is leached to obtain potassium in soluble form as alum instead of as the simple sulphate. The solution, which usually contains an excess of aluminum sulphate, is brought to saturation in a countercurrent system of leaching vats and is then filtered off hot. On cooling, the solution deposits crystals of potash alum mixed with more or less aluminum sulphate. The mixture is then roasted at a temperature a little above 750° C. and yields a solid residue of pure alumina and potassium sulphate, which

[1] Abstract from unpublished report of F. K. Cameron to Bureau of Mines.

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is separated by a second leaching and crystallization. An advantage claimed for this process is that it produces a finished high-grade alumina simultaneously with the potassium sulphate.

MacDOWELL PROCESS.

By the MacDowell process ground alunite is roasted at a temperature sufficiently high to drive off the excess of sulphur as oxides. The temperature is then raised and the potassium salt and some sodium are volatilized, condensed, and passed through a collecting apparatus.

OTHER PROCESSES.

A wet process has also been proposed, by which finely ground alunite is heated with a measured quantity of chamber sulphuric acid to a temperature of about 200° C., a treatment which converts the potassium and alumina to alum and aluminum sulphate. When the mass is triturated with water most of the silica and iron remain insoluble. The alum and aluminum sulphate are purified by crystallization and may be converted to potassium sulphate and alumina as described above.

RECENT PATENTS FOR THE REDUCTION OF ALUNITE.

The following patents for processes of reducing alunite have been recently issued by the United States:

Patent No. 1161239, dated November 23, 1916, to G. S. Morgan; patent No. 1175439, dated March 14, 1916, to C. F. Hagedorn; patent No. 1189254, dated July 4, 1916, to P. R. Hershman and Raymond Cooke; patent No. 1191104, dated July 11, 1916, to P. R. Hershman; patent No. 1195655, dated August 22, 1916, to H. F. Chappell.

POTASH FROM FELDSPAR AND OTHER SILICATE MATERIALS.

GENERAL STATEMENT.

Fifty years ago a treatise on industrial chemistry,[1] after referring to the ashes of plants as the main source of potash salts, said: "It is, however, to the potash feldspars that chemists have long looked as a source of potash if any cheap industrial process could be found for extracting the alkali from these minerals." At that time the potash of the Stassfurt salts was known but was regarded as an unlikely commercial source of potash for several reasons, as stated in the same treatise, but the statement about the potash feldspars is as true to-day as it was at the time that book was written.

Potash salts can be readily extracted from silicate or aluminosilicate minerals by any one of several processes. To-day, as 50 years ago, the difference between the cost of production and the market price of the product must determine the practicability of profitably extracting it. Feldspar averaging 10 per cent or more of potash can be obtained, but as it is required in very large quantities and must be obtained by cheap methods of mining, which do not require hand

[1] Richardson, Thomas, and Watts, Henry, Treatise on acids, alkalies, and salts, 2d ed., vol. 1, p. 551, London, 1867.

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sorting, it is somewhat doubtful whether even the most promising deposits will yield material that would average much more than 7 per cent K_2O. The expense of handling and treating large quantities of such rock in order to recover the small percentage of water-soluble potash it contains has seemed well-nigh prohibitive—at least it has not yet been possible to market any such product in competition with the foreign potash salts. A number of projects are on foot, however, to produce potash from silicate materials, and these projects should not yet be condemned because of their temporary failure to achieve commercial results.

DISTRIBUTION OF POTASH IN ROCKS AND MINERALS.

Potash (as K_2O) forms from 2.65 to 2.98 per cent of the earth's crust. The average potash content of the igneous rocks is about 3 per cent and rocks of this class form about 95 per cent of the earth's crust. Of the sedimentary rocks, which have been derived from the igneous rocks, shales carry 3.24 per cent of potash, sandstones 1.31 per cent, and limestones 0.33 per cent. Thus most of the potash that is liberated from the primary rocks and becomes refixed in sedimentary rocks goes into the shales, which are composed of fine particles that once formed muds. A part of it, of course, remains in soluble form in the ocean and in saline solutions and deposits or is temporarily transferred to organic forms. Potash, however, has an affinity for clayey or muddy sediments in which it becomes more or less permanently fixed. In this very fact may be found a reason why accumulations of soluble potash in deposits are so rare, whereas the soluble sodium salts are relatively abundant.

Potash in a form that is insoluble in water—the form in which it occurs in igneous rocks or is fixed in sedimentary rocks—is usually considered unavailable for use in the manufacturing industries or in agriculture. Doubtless much of the potash that is contained in soils has been liberated from insoluble form by slow mineral decomposition, but it seems that for immediate and practical use as fertilizer potash must be in water-soluble form, and this form is demanded by the fertilizer industry. Although there has been some controversy over the matter, it is now generally assumed that a potash-bearing rock, even if it contains more than 3 per cent of insoluble potash, is of very doubtful value as fertilizer until it has been so treated that the potash has been made soluble and so available for ready assimilation by plants. Neither are the insoluble forms of potash available for use in manufacturing industries. The problem of making insoluble potash soluble and thus available for use in agriculture and in manufactures has therefore been widely and carefully studied.

A number of common rocks or minerals that contain insoluble potash in considerable quantities are listed below.

1. Minerals that, if theoretically pure (as they seldom are in nature), may carry the maximum quantities of potash indicated:

Feldspar (potash-bearing varieties) 16.9 per cent K_2O.
Leucite ($K_2O.Al_2O_3.4SiO_2$) 21.5 per cent K_2O.
Sericite (muscovite) ($2H_2O.K_2O.3Al_2O_3.6SiO_2$) 11.8 per cent K_2O.
Nepheline, 7.7 per cent K_2O.

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2. Rocks in which the minerals named above are usually found in considerable quantity:

Pegmatites, which are composed largely of potash feldspar and mica.
Leucite rocks of various composition, which carry much potash in the leucite, feldspar, and mica that they contain.
Sericite schists, whose value as a source of potash depends largely on a predominance of the minerals sericite and feldspar.
Mica schists containing both potash mica and feldspar, which may carry a high content of potash.
Greensand, a sand containing grains of glauconite, which carries potash.

Many nephelites, syenites, granites, and gneisses, as well as sedimentary rocks, also carry high percentages of potash, and some of them doubtless deserve consideration in connection with projects for obtaining potash, either directly or as a by-product, from potash-rich silicate rocks.

AREAS OF POTASH-RICH SILICATE ROCKS.

FELDSPAR.

The statement has been repeatedly made that the supply of potash-rich silicate rocks, particularly feldspars, is inexhaustible. This statement is undoubtedly true if the stated content of potash is not set too high. Some bodies or areas of pegmatite might supply large quantities of feldspar, but careful investigation of developed deposits has shown that the rock worked contains a large proportion of quartz and soda-bearing feldspar and that the feldspar which carries 10 per cent of potash can usually be obtained only by careful hand sorting, which increases the cost of mining and puts a limit on the output from any particular deposit. F. J. Katz, of the United States Geological Survey, who has examined many bodies of pegmatite, reports that the best pegmatites seen by him promise to yield about 7 per cent or less of potash in a run-of-quarry product, and that the potash in these rocks is almost everywhere closely associated with 2 or more per cent of soda. Even the most carefully selected feldspar contains considerable quantities of soda, which occurs in the form of crystals of albite (soda feldspar) intimately intergrown with crystals of orthoclase or microcline (potash feldspars).

The following analyses represent the composition of average samples of pegmatite collected by Mr. Katz in 1916. They may be considered more truly representative than most other published analyses of pegmatite and were made for publication by him in a report giving also other results of work on pegmatites and discussing the available sources of potash feldspar. The samples are all from Connecticut, but analyses of pegmatite obtained elsewhere give similar results.

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Representative analyses of typical Connecticut pegmatites.

[R. C. Wells, analyst.]

	1	2	3		1	2	3
SiO_2	72.42	71.00	75.20	K_2O	6.24	7.65	4.55
Al_2O_3	15.88	16.06	13.81	$H_2O\pm$	.46	.34	.45
$FeO+Fe_2O_3$	.54	.63	.86	TiO_2	.05	.04	.17
MgO	Trace.	.02	None.		99.98	99.81	99.71
CaO	.65	.32	.62				
Na_2O	3.74	3.75	4.05				

1. 50-pound sample; average cross section cut in the Howe quarry, South Glastonbury, Conn.
2. 120-pound sample; average cross section cut in the Strickland quarry, Portland, Conn.
3. 45-pound sample; average cross section cut in the Eureka quarries, Middle Haddam, Conn.

Private reports on the sampling of 10 carload lots of feldspar from another part of the country, shipped and sold for its potash, showed that the potash ranged from 4.8 to 10.16 per cent and averaged 6.5 per cent, but that the material had been to some extent selected or sorted.

Thus a critical examination of many known deposits of feldspar pegmatite indicates that not so much of that rock carries a high percentage of potash as has been commonly assumed, although much pure feldspar can undoubtedly be obtained by sorting the rock from certain large pegmatite dikes, some of which may afford material to support the commercial production of potash and alumina.

Mr. Katz suggests that the regions near the places indicated below, at which feldspar has been mined for use in making pottery, may contain deposits of potash feldspar in sufficient quantity to justify the erection of plants for extracting potash.

Georgetown and Topsham, Sagadahoc County, Maine.
Auburn, Androscoggin County, Maine.
Grafton Center, N. H.
Middletown, Conn.
Fulton and Saratoga counties, near Northville, N. Y.
Marriottsville, Md.
Bedford and Amelia counties, Va.
Spruce Pine district, Mitchell and neighboring counties, N. C.
Franklin, Macon County, N. C.

This list is by no means complete, and many other localities undoubtedly deserve investigation.

POTASH-RICH VOLCANIC ROCKS.

The rocks of the Leucite Hills, Wyo., have been repeatedly referred to as an available source of potash, and are described in a publication of the United States Geological Survey.[1]

The tailings or waste at many mines in this region that treat large quantities of low-grade porphyry ore form great heaps of finely ground feldspathic rock, some of which carry a rather high percentage of potash. Butler[2] has suggested that if any process for recovering the potash salts from such rock could be devised its operators would

[1] Schultz, A. R., and Cross, Whitman, Potash-bearing rocks of the Leucite Hills, Sweetwater County, Wyo.: U. S. Geol. Survey Bull. 512, 39 pp., 1912.
[2] Butler, B. S., Potash in certain copper and gold ores: U. S. Geol. Survey Bull. 620, pp. 227–236, 1915.

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find in these heaps of tailings a large supply of raw material, already finely ground and accessible to lines of transportation and to cheap power and water. Analyses of representative samples of the ore-bearing rocks are given by Butler.

An analysis of a sample of finely ground tailings recently received from a mill in the Cripple Creek district, Colo., made by W. B. Hicks in the laboratory of the Geological Survey, showed that it contained 12.08 per cent potash (K_2O). Steps have been taken to check the sample and determine, if possible, the quantity of available material represented by it. Samples from the mill of the Utah Copper Co., at Garfield, Utah, contain 5.88 to 6.81 per cent potash; and samples from the plant of the Chino Copper Co., at Hurley, N. Mex., contain 4.42 per cent.

If it should prove economically feasible to work rock of this class for its potash, other areas of potash-rich volcanic rock that have not been so much discussed as the Leucite Hills might be worthy of investigation. Among these may be mentioned the tinguaite-porphyry of the Judith Mountains, Mont., described by Weed and Pirsson.[1] This rock occurs as dikes and sheets cutting the intrusive masses of Judith Peak, Red Mountain, Elk Peak, and Cone Butte. Two analyses quoted by these authors show that it contains 9.16 and 9.44 per cent of potash (K_2O). The same authors give an analysis of a similar potash-rich leucite tinguaite from Magnet Cove, Ark.

SERICITE.

Sericite, a finely divided form of muscovite mica, is reported to occur at many places in massive deposits, most of them more or less impure, which have been somewhat exploited as a possible source of potash. It occurs in highly schistose bands in metamorphosed sedimentary rocks. Sericite is of somewhat indefinite composition, but is supposed to contain, if pure, a theoretical maximum of 11.8 per cent potash (K_2O).

Sericitic rocks occur throughout the eastern part of the Appalachian Mountains. The sericite is generally mixed with other minerals and forms only a small part of the rock, but in places the proportion of other minerals is much less and the rock here and there consists almost entirely of sericite. A search for some of these rich deposits of sericite was made in the spring of 1916 by the United States Geological Survey in parts of North Carolina, South Carolina, and Georgia. The deposit in Georgia, which contains the highest percentage of potash yet found in any deposit so far examined, is in the north-central part of the State, near Jasper. This region has been recently examined with special care by the Geological Survey of Georgia.

The deposit nearest Jasper is about 4 miles southwest of the town. The best sericite schist occurs on one property as a band about 4 feet thick, but the band is said to be thicker farther southwest. It is exposed at intervals for a distance of about 3 miles. Several analyses of this sericite have been made.

[1] Weed, W. H., and Pirsson, L. V., Geology and mineral resources of the Judith Mountains, Mont.: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 3, pp. 567–671, 1898.

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Analyses of sericite from deposit near Jasper, Ga.

	1	2	3		1	2	3
Moisture at 100° C.	0.12	2.27	0.40	Ferrous oxide (FeO)	0.72	0.33	2.00
Loss on ignition	3.96		3.18	Manganous oxide (MnO)	Trace.	Trace.	.00
Soda (Na_2O)	.20	1.15	.32	Titanium dioxide (TiO_2)	.56	.....	.20
Potash (K_2O)	10.75	9.82	10.31	Sulphur trioxide	.....	.....	.07
Lime (CaO)	.00	.40	.00	Silica (SiO_2)	46.17	52.96	46.75
Magnesia (MgO)	.40	1.21	1.15		100.13	100.16	100.36
Alumina (Al_2O_3)	34.29	29.16	34.94				
Ferric oxide (Fe_2O_3)	2.96	2.86	1.04				

1. Sample of sericite from the William Richards property, Pickens County, Ga.; analyzed at the laboratory of the Geological Survey of Georgia. Edgar Everhart, analyst.
2. Sample collected by P. S. Smith to represent the 4-foot band of purest material. R. K. Bailey, analyst, laboratory of the United States Geological Survey.
3. Sample of sericite from the vicinity of Jasper; analysis received from the American Mica Co.

One or more trial shipments of sericite have been made from the deposits near Jasper, and lately a considerable quantity has been ground, presumably for the purpose of testing its availability as a source of potash, or as a constituent of potash fertilizer.

OTHER SCHISTS AND SEDIMENTARY ROCKS RICH IN POTASH.

Schists and slates or shales that carry high percentages of potash are reported to occur at several places, but these reports have not yet been confirmed by systematic sampling and analysis. A deposit of phyllite that carries 7 per cent potash is reported to occur near Union Bridge, Md., and a project is under way to utilize the mineral as a constituent of a cement made at an established Portland cement works with a view to obtaining potash in the resulting dust and fume.

GLAUCONITE (GREENSAND MARL).

Glauconite, commonly called greensand or greensand marl, has long been used as a fertilizer, particularly as a source of potash and lime and to a less extent of phosphoric acid. It is widely distributed in sedimentary deposits, but is concentrated in considerable purity at certain places, notably in New Jersey and Delaware. Its occurrence has been reported in Maryland, Virginia, Tennessee, North Carolina, South Carolina, Alabama, and Mississippi, but few authentic data regarding the extent or character of the deposits are available. Samples and analyses were recently obtained from one deposit in Virginia and one in North Carolina. A deposit in Arkansas has also been sampled, and deposits are reported to occur near San Antonio, Tex.

A report on the distribution and composition of greensand deposits in the eastern United States,[1] now in press, gives the results of examinations, sampling, and analyses of greensand from some of the principal deposits. This report shows that the high percentages of potash given in many of the older analyses of greensand are erroneous. Careful sampling and analysis show that the best greensands are in New Jersey and Delaware, where the maximum thickness of the deposits is in places 20 to 30 feet, though it is generally less. These deposits have a horizontal extent of many miles, but

[1] Ashley, G. H., Notes on the greensand deposits of the eastern United States; methods of analysis of greensand, by W. B. Hicks and R. K. Bailey: U. S. Geol. Survey Bull. 660, pp. 27–58, 1917 (Bull. 660–B).

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vary considerably in character. Some of the best greensands in New Jersey consist of almost pure glauconite, which yields on analysis 7 per cent of potash. Over wide areas, indeed, their content of potash ranges from 5 to 7 per cent. The deposits are close to lines of transportation and are so situated that they could be mined cheaply by dredge or steam shovel. The deposits examined in Delaware are of lower grade than those in New Jersey.

Samples from Maryland yielded 4.45 per cent potash and less, indicating a maximum content of about 50 per cent glauconite.

Glauconitic greensand is reported to occur in Virginia chiefly along the inner margin of the Coastal Plain region. It is found along Potomac, Rappahannock, Pamunkey, and James rivers, and on interstream areas, and has been worked at several places, especially on James and Pamunkey rivers. Samples obtained from one deposit on Potomac River below Washington, in Virginia, which contains much lime, yielded 0.2 to 2.5 per cent potash.

Glauconite is reported to occur in the southeastern counties of North Carolina, from Neuse River to Cape Fear River. Samples taken by G. H. Ashley from a deposit near Grifton, a station on the Atlantic Coast Line Railroad a few miles northeast of Kinston, contained 2.96 per cent potash and probably represent a glauconite sand about 40 per cent pure.

Glauconitic sand occurs in certain formations of the Claiborne group in South Carolina, particularly in a district southeast of Columbia, but perhaps the deposits have not been exploited or the sand may contain relatively little glauconite.

Greensand was reported by Troost[1] in 1844 as occurring in association with the Selma chalk in Chester, Henderson, and McNairy counties, Tenn., but a recent search has failed to show that these deposits contain greensand.

Greensand is reported to occur throughout an area covering many counties in southern Alabama, but it is mostly disseminated in other sands of which it forms only a small part.

Glauconite, or greensand marl, is reported to occur in Mississippi, but no definite data as to the deposits are available.

A deposit of greensand in southwestern Arkansas, near Washington, in Hempstead County, was recently examined and sampled by Dr. Ashley. The samples gave a maximum of about 4.5 per cent potash, equivalent to a glauconite sand about 60 per cent pure.

A report of a deposit of greensand 7 miles from San Antonio, Tex., accompanied by an analysis showing 10.77 per cent of potash (K_2O), was received by the Survey in December, 1915. The deposit is said to be in a hill that extends for about three-quarters of a mile along the bank of a creek. The name of the analyst is unknown and if the material is to be investigated further, it would be advisable to make check analyses.

PROCESSES OF EXTRACTING POTASH FROM SILICATES.

The processes proposed for extracting potash from feldspar and other silicate minerals involve (*a*) direct methods of treatment for obtaining potash as a main product, although the descriptions of

[1] Troost, Gerard, Tennessee Geol. Survey Seventh Rept., p. 30, 1844.

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them generally contain reference to some other use of the residues, or (*b*) methods of saving potash as a by-product in the production of some other valuable commodity.

In 1916 considerable progress was made in the development of the processes of producing by-product potash from cement-kiln dust and gases and from furnace-flue dust generally. These developments are considered in greater detail on pages 133–139.

The following is a list of some of the more important patents for processes of extracting potash from silicates, such as feldspar, leucite, sericite, and greensand. These processes may be grouped into the three classes indicated below, though some of them can not be limited to one class but overlap to another:

1. Treatment by the wet method, which involves treating the raw material with some reagent in a wet mix, usually under more or less pressure.

2. Heating with one or more reagents without volatilization of the potash, which is afterwards recovered from the frit by lixiviation, the potash salt being recovered from the solution.

3. Heating, generally with reagents, to a degree sufficient to volatilize the potash, which is then condensed and collected from the gases by electric precipitators or other apparatus. This process includes the recovery of potash from cement and blast furnaces.

PATENTS FOR PROCESSES.

The processes are best represented by patents that have been granted. Actual tests of a few of the proposed processes have been made, and the results have been discussed in the technical journals. Any of these processes that may be put into actual use will doubtless be modified through the experience gained in its practical operation. The patents listed below are arranged according to the classification just given. Printed copies of these patents may be obtained from the United States Patent Office for 5 cents each.

1. United States patents for treating silicates, by other means than furnacing, for possible subsequent extraction of potash salts.

772206, Oct. 11, 1904, Blackmore, H. S. Feldspar is heated, cooled, mixed with water and subjected to action of carbon dioxide.

772612, Oct. 18, 1904, Gibbs, W. T. Powdered feldspar is boiled with sulphuric and hydrofluosilicic acids.

772657, Oct. 18, 1904, Gibbs, W. T. Powdered feldspar is treated with hydrofluosilicic acid. (*See* Jour. Ind. and Eng. Chemistry, vol. 4, p. 377, May, 1912.)

851922, Apr. 30, 1907, Cushman, A. S. Potash is recovered by electrolysis. (*See* Am. Chem. Soc. Jour., vol. 30, p. 779, 1908.)

910662, Jan. 26, 1909, Gibbs, W. T. Silicates are digested with milk of lime under steam pressure to obtain caustic potash.

947795, Feb. 1, 1910, Coates, L. R. Silicates are broken up by use of bacterial cultures.

993463, May 30, 1911, Schäcke, F. Eruptive rocks carrying at least 4 per cent of potash are finely ground and mixed with lime and other material to form manure.

1029378, June 11, 1912, Lawton, C. F. Crushed feldspar, etc., is mixed with organic material and fermented to liberate plant food.

1030122, June 18, 1912, Peacock, Samuel. Feldspar is ground and after being strongly heated is treated with concentrated solutions of potassium or sodium carbonate under low pressure.

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1036879, Aug. 27, 1912, Peacock, Samuel. Alkali aluminate derived from feldspar is treated with carbon dioxide and potash is separated by digestion.
1054518, Feb. 25, 1913, Doremus, C. A. Feldspar is treated with hydrofluoric acid to form potassium silico-fluoride (?) and a soluble aluminum compound, and the residue is treated with sulphuric acid.
1076508, Oct. 21, 1913, Messerschmitt, A. Feldspar powdered with calcium nitrate, water, and lime is digested under pressure to obtain potassium nitrate.
1083691, Jan. 6, 1914, McIlliney, P. C. Alumina is separated from feldspar, potash being obtained as a by-product.
1148156, July 27, 1915, Dougherty, E. E. Leucite is treated with sulphuric acid and hydrochloric acid.
1174795, Mar. 7, 1916, Anderson, E. L. Feldspar is decomposed with small amounts of hydrofluoric acid in the presence of sulphuric acid.
1182668, May 9, 1916, Firebaugh, F. L. Nepheline, leucite, and other minerals are leached with sulphuric acid.
1197556, Sept. 5, 1916, Slater, H. B. Alkali, particularly potash, is obtained from minerals or mineral residues by electrolysis, in a solvent rich in chlorides.

2. United States patents for treating silicates by heat without volatilization of potash, which is recovered by leaching the frit.

5381, Dec. 4, 1847, Tilghman, R. A. Feldspar is treated with sulphate or muriate of another base.
16111, Nov. 25, 1856, Bickell, C. Feldspar, calcium phosphate, and lime are heated together in a furnace and leached or used for fertilizer.
43534, July 12, 1864, Vanderburgh, G. E. Ground feldspar and soda ash are vitrified and then digested with steam.
49891, Sept. 12, 1865, Klett, Frederick. Feldspar, lime, calcium fluoride, and phosphate of lime are heated to make fertilizer.
376409, Jan. 10, 1888, Kayser, A. Alumina is produced from clays and potash is separated as a by-product. (*See* Eng. and Min. Jour., vol. 94, pp. 535–536, 1909.)
513001, Jan. 16, 1894, Blackmore, H. S. Powdered feldspar, calcium chloride, lime, and water are heated under pressure.
521712, June 19, 1894, Helbling, J. Clay, ammonium sulphate, and potassium sulphate are heated together.
641406, Jan. 16, 1900, Rhodin, J. G. A. Feldspar, lime, and sodium chloride are heated together and then leached with acid. (See Soc. Chem. Industry Jour., vol. 20, p. 439, 1901.)
847856, Mar. 19, 1907, Wadman, W. E. Soluble lithia salts are obtained from lepidolite, potash alum being a by-product.
862676, Aug. 6, 1907, Swayze, A. J. Feldspar is first heated and is then treated with caustic potash under pressure.
869011, Oct. 22, 1907, McKee, R. H. Potash-bearing mineral containing mica is heated with lime and salt.
959841, May 31, 1910, Carpenter, F. R. Granitic potash is made more soluble by heating and sudden chilling.
987436, Mar 21, 1911, Cushman, A. S. Feldspar is decomposed by heating with lime, salt, and calcium chloride.
995105, June 13, 1911, Thompson, Firmin. Ground feldspar is heated with sodium acid sulphate and sodium chloride.
997671, July 11, 1911, Hart, E. Orthoclase is fused with barium sulphate and coal. (*See* Am. Ceramic Soc. Trans., vol. 13, p. 683, 1910, and Eighth Internat. Cong. Appl. Chemistry Trans., vol. 2, p. 117, 1912; Jour. Ind. and Eng. Chemistry, vol. 7, p. 679, August, 1915.)
1034281, July 30, 1912, Neil, J. M. Crushed feldspar is added to melted sulphate or bisulphate of alkali metal and fused.
1035812, Aug. 13, 1912, Peacock, Samuel. Ground feldspar and calcium carbonate are calcined and are then boiled with added soda or potash.
1040893, Oct. 8, 1912, Cowles, A. H. Mixture of feldspar and phosphate rock is ground and sintered, and is then leached with acid.
1040894, Oct. 8, 1912, Cowles, A. H. Crushed feldspar is added to melted sulphate or bisulphate of alkali metal and is then fused.
1040977, Oct. 8, 1912, Cowles, A. H. Similar process to 1040894.

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1041327, Oct. 15, 1912, Morse and Sargent. Feldspar is heated with gypsum and, in a separate operation, with sodium chloride.
1041598, Oct. 15, 1912, Cowles, A. H. A mixture of feldspar and phosphate rock is sintered and is then treated with acid.
1041599, Oct. 15, 1912, Cowles and Kayser. Similar process to 1041598.
1046327, Dec. 13, 1912, Peacock, Benjamin. Silicates are heated with phosphate rock and are then treated with steam.
1058686, Apr. 8, 1913, Gelléri, S. Silicates are heated with lime and are then treated with vapor of ammonium carbonate under pressure.
1062278, May 20, 1913, Hart, Edward. Feldspar is heated with potassium or sodium sulphate and carbon, is then treated with acid, and yields potash alum.
1072686, Sept. 9, 1913, Bassett, H. P. A mixture of feldspar and salt is heated and is then leached with water.
1078495, Nov. 11, 1913, Gelléri, S. Silicates are treated with vapor of ammonium carbonate under pressure and yield alkali carbonate; various reagents are used.
1078496, Process similar to 1078495.
1083287, Jan. 6, 1914, Lindblad, A. R. Feldspar, iron, and charcoal are heated together.
1087132, Feb. 17, 1914, Messerschmitt, A. Alkali metal nitrates are prepared from the product obtained by decomposing silicates with limestone.
1089716, Mar. 10, 1914, Messerschmitt, A. Feldspar, limestone, and other materials are calcined and leached.
1091033, Mar. 24, 1914, Bassett, H. P. Ground feldspar is mixed with sodium acid sulphate, sodium chloride, and carbon and heated, and the product is leached with water.
1091034, Mar. 24, 1914, Bassett, H. P. Process similar to 1091033.
1091230, Mar. 24, 1914, Messerschmitt, A. Feldspar and by-product calcium carbonate are heated and then leached with water.
1095306, May 5, 1914, Bassett, H. P. Aluminous silicates are fused with carbonate and chloride of soda and the clinker is leached with water.
1103910, July 14, 1914, Willson and Haff. A mixture of feldspar and phosphate rock is fused, ground, and treated with sulphur dioxide.
1106984, Aug. 11, 1914, Stillman, T. B. Potash-bearing silicate is ground and mixed with alkali carbonate and melted, and is then pulverized and treated with water.
1111881, Sept. 29, 1914, Cowles, A. H. Feldspar and clay are furnaced in vapors of salt and water.
1111490, Sept. 22, 1914, Perino, Josef. Finely ground feldspar is mixed with magnesium chloride and is then heated in steam.
1123693, Jan. 5, 1915, Cowles, A. H. Feldspar and clay are heated in the presence of salt and water. (*See* Eighth Internat. Cong. Appl. Chemistry Trans., vol. 25, p. 119, 1912; also Met. and Chem. Eng., vol. 10, p. 659, 1912.)
1125007, Jan. 12, 1915, Coolbaugh and Quinney. Silicate rock is heated with gypsum or lime and is then leached with dilute sulphuric acid.
1125318, Jan. 19, 1915, Herzefeld and Hauser. Powdered feldspar is heated with mother liquor obtained in producing potassium chloride from crude carnallite.
1129224, Feb. 23, 1915, Peacock, Samuel. Feldspar or other silicate minerals are heated with ground coke or coal in a reducing atmosphere, yielding a carbide of potassium.
1129505, Process similar to 1129224.
1129721, Process similar to 1129224.
1134413, Apr. 6, 1915, Peacock, Samuel. Silicate is heated with finely ground coke in a reducing atmosphere, as above.
1144405, June 29, 1915, Wilson and Haff. Potash mineral and calcium phosphate are heated together.
1148850, Aug. 3, 1915, Melkman, S. E. Silicates are heated with concentrated sulphuric acid and then roasted.
1150815, Aug. 17, 1915, Drury, C. W. Feldspar is heated with lime and iron ores in blast furnace, yielding potash in siliceous slag, which is useful as fertilizer.
1151498, Aug. 24, 1915, Rody and Burkey. Silicate is heated with lime and sodium carbonate.

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1151533, Aug. 24, 1915, Rody, F. A. Silicate is treated with alkali earth chloride without lime.
1159464, Nov. 9, 1915, Bassett, H. P. Greensand is heated with sodium acid sulphate and sodium chloride.
1160171, Nov. 16, 1915, Heyman, A. W. Silicates are furnaced with lime and are then leached, leaving cement-making material.
1160172, Process similar to 1160171.
1165154, Dec. 21, 1915, Coolbaugh and Quinney. Feldspar and gypsum are heated and then are leached with dilute sulphuric acid. (*See* Chem. Engineering, vol. 21, p. 171, April, 1915.)
1172420, Feb. 22, 1916, Bassett, H. P. Feldspar and phosphate rock are heated together.
1194464, Aug. 15, 1916, Bassett, H. P. A silicate is heated with sodium acid sulphate and sodium fluoride or calcium fluoride.
1196734, Aug. 29, 1916, Frazer, J. C. W., and others. Silicates are heated with dry caustic alkali at moderate temperature and the product is leached. (*See* special pamphlet issued under title "The Hopkins process.")
1201396, Oct. 17, 1916, Kolnitz, G. F. von. Greensand is heated with calcium chloride to produce potassium chloride.
1202215, Oct. 24, 1916, Peacock, Samuel. Greensand is melted in a closed furnace under pressure; the potash is extracted by means of alkali solution and later is treated with milk of lime to recover alkali hydroxide.
1209201, Dec. 19, 1916, Radman, P. A mixture of silicates and powdered gypsum is heated at a temperature below fusing point and then leached with water.

3. United States patents for treating silicates by heat with volatilization of potash, which is condensed and collected by electrical precipitation or other means.

789074, May 2, 1905, Swayze, A. J. Feldspar, gypsum, and carbon are heated and then volatilized, the potassium salts being collected from exit pipe of furnace in water spray.
912266, Feb. 9, 1909, Spencer, A. C., and Eckel, E. C. Potash is volatilized from hydraulic cement mixture containing greensand.
999494, Aug. 1, 1911, Ellis, C. Cement materials are heated in electric furnace for recovering potash.
1011172, Dec. 12, 1911, Eckel, E. C. Glauconite is heated and potash volatilized and then condensed from the vapor.
1011172, Dec. 12, 1911, Eckel, E. C. Glauconite and limestone are treated in a blast furnace to produce potash and also pig iron.
1018186, Feb. 20, 1912, Haff, M. M. Orthoclase and calcium phosphate are fused to produce volatilized phosphoric acid and potash, which are collected by a water spray.
1035812, Aug. 13, 1912, Peacock, Samuel. Feldspar and limestone are heated to volatilize the potash which is condensed, and the residue is worked up for other products.
1036897, Aug. 27, 1912. Process similar to 1035812.
1064550, June 10, 1913, Schott, F. A system of collecting cement dust.
1121532, Dec. 5, 1914, Newberry, S. B. Potash is volatilized with furnace gases, collected, and leached.
1123841, Jan. 5, 1915, Brown, H. E. Calcium chloride, calcium carbonate, and feldspar are fused and volatilized potash is condensed.
1124238, Process similar to 1123841.
1124798, Jan. 12, 1915, Peacock, Samuel. The insoluble potassium contained in cement flue dust is digested with a solution of monocalcium phosphate.
1140532, July 18, 1915, Spencer, A. C. A potassiferous natural magnesian cement rock is treated to obtain potash and by-products.
1150295, Aug. 17, 1915, Newberry, S. B. Alkalies are recovered from cement kilns by means of water spray or on wet porous surfaces.
1156108, Oct. 12, 1915, Spencer and McElroy. Potassium cyanide is retained from silicates in a blast furnace.
1157437, Oct. 19, 1915, Spencer, A. C. Silicates are treated with lime in less amount than that needed to form Portland cement.

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1186522, June 6, 1916, Ellis, C. Hydraulic cement is made from potassium silicates by melting with lime and calcium chloride, and potassium chloride is collected from fumes by water spray.

1194344, Aug. 8, 1916, Huber and Reath. Silicates are heated with calcium fluoride and calcium carbonate; Portland cement is obtained from residue.

1200887, Oct. 10, 1916, Schmidt, W. A. Feldspar or similar minerals are heated as in the manufacture of cement, but with the added factor of hot gases containing sulphur dioxide, which increases the amount of potash obtained by condensation and collection of the fumes.

1202327, Oct. 24, 1916, Spackman and Conwell. Potash obtained from cement materials is made soluble by regulating temperature and using water vapor in the kiln.

1209135, Dec. 19, 1916, Eckel and Spencer. Cement clinker and potassium compounds are made from raw mixture containing feldspar.

1209219, Dec. 19, 1916, Spencer and Eckel. In making cement from greensand or other rocks recovery of potash is facilitated by mixing in a small proportion of calcium chloride.

1209220, Dec. 19, 1916, Spencer, A. C. "Feldspathoid" rocks (leucite, nephelite, etc.) are used in cement mixtures and potash is volatilized and recovered.

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Ross, W. H., Potash from silicate rock: Eighth Internat. Cong. App. Chem., vol. 15, p. 217; U. S. Dept. Agr. Bur. Soils Circ. 71; Am. Fertilizer, vol. 37, No. 4, p. 44.

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SPECIAL ACTIVITIES IN 1916.

KAOLIN PRODUCTS CORPORATION.

The Kaolin Products Corporation is operating a plant at Jones Point, N. Y., on Hudson River about 40 miles above New York City. The plant was designed to produce about a ton of potash a day, but it is only experimental and was not intended for commercial production. A wet mixture of finely ground feldspar or greensand and caustic lime is heated under pressure to make the potash soluble. The solution, which is somewhat dilute, is then concentrated and the potash is obtained as caustic, or it may be obtained as carbonate by treatment with the carbon dioxide derived from burning the lime. This, in its essentials, is an old process, but it appears to offer much promise if a market can be found for the by-products. Samples of building brick made by molding the residue under pressure and then steaming are reported to have been tested and to have given very satisfactory results.

WAVERLY CHEMICAL CO., CAMDEN, N. J.

A plant at Camden, N. J., directed by Samuel Peacock, has been regularly producing from greensand (glauconite) dug near Sewell, N. J., a small output of hydrated carbonate of potash for the cut-glass industry. Glassmakers' potash salt formerly sold for 3 to 4 cents a pound, but now brings 35 to 45 cents. The proprietors of this plant regard it as temporary, for the product doubtless can not compete with the foreign salt when the price falls below 5 cents.

ATLANTIC POTASH CO. (INC), STOCKERTOWN, PA.

It is reported that the Atlantic Potash Co., incorporated late in 1916 to make potash and other chemicals, has purchased the old plant of the Northampton Portland Cement Co., at Northampton, or Stockertown, Pa. It is said that the company will repair four kilns

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in which to treat greensand from New Jersey under the process covered by United States patent No. 1011172 (see p. 128). According to present plans the potash will be volatilized as in the ordinary cement kiln and the fume condensed and recovered by some washing method.

EXPERIMENTAL WORK AT SEWAREN, N. J.

Alfred H. Cowles, president of the Electric Smelting & Aluminum Co., has taken out several patents for cheaply extracting alumina from silicates like clay and feldspar to make aluminum by processes that will also recover potash. Experimental plants at Sewaren, N. J., and at Lockport, N. Y., have been devoted to this work. Mr. Cowles[1] has published articles on the production of potash alum from feldspar and rock phosphate and also of a potash phosphate fertilizer. Patents recently obtained (see p. 126) indicate that the experimental work is still going on.

DOREMUS PROCESS.

It is reported that laboratory and factory tests have been made of the Doremus process for producing alumina from silicates (patent No. 1054518, dated Feb. 25, 1913) on a scale and in a way to determine the cost of production. This process has more recently been so modified as to recover potash. Finely ground feldspar is added to hydrofluoric acid of about 20 per cent strength, in which it rapidly decomposes. The potash unites with the hydrofluosilicic acid, forming the highly insoluble compound potassium silicofluorid. The alumina of the feldspar is dissolved as aluminum fluorid. The silica in excess of that which unites with the potash is mixed with the potassium silicofluorid or goes into solution as hydrofluosilicic acid and is mixed with the aluminum fluorid, the potash and the alumina being thus separated.

The potassium is recovered by heating the potassium silicofluorid to dull redness with calcium sulphate (gypsum or anhydrite), whereupon it becomes soluble potassium sulphate, and one-third of the fluorine is fixed as calcium fluoride and two-thirds as silicon fluoride, which may be recovered to be used again.

After the solution has been neutralized by aluminous ore to separate the silica the aluminum fluorid is crystallized from it, and by heating these crystals with steam, hydrofluoric acid is recovered, and alumina is obtained in a form available for making aluminum or the salts of aluminum. These salts are considered the principal product of the process.

EXPERIMENTAL PLANT AT ALLENTOWN, PA.

Experiments for obtaining potash from feldspar have been made from time to time at Allentown, Pa., and late in 1916 tests were there made of a process or processes devised by Dr. Walter Glaeser. It is said that the establishment of a considerable project for extracting potash from feldspar depends on the results of these tests. The feldspar intended to be used is obtained from quarries at Maromas, Conn.

[1] Cowles, A. H., Cheaper alumina and aluminum from mineral silicates: Met. and Chem. Eng., vol. 11, No. 3, pp. 140–143, March, 1913. Same paper in Jour. Ind. and Eng. Chemistry, vol. 5, p. 331, Apr. 1, 1913.

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POTASH & CHEMICAL PRODUCTS CO., MIDDLESEX COUNTY, CONN.

The Potash & Chemical Products Co., of Maine, with headquarters and plant at Essex, Middlesex County, Conn., is said to be engaged in treating feldspar and salt-marsh muck, by a process not yet disclosed, for the manufacture of a fertilizer containing, according to a reported analysis, 7.34 per cent of available potash (K_2O) and 2.72 per cent of ammonia.

EXPERIMENTAL WORK AT RUMFORD FALLS, ME.

Experiments were made by the Fort Hill Chemical Co. at Rumford Falls, Me., with a view to utilizing some local rock as a source of potash, but with unsatisfactory results.

TREATMENT OF GROUND FELDSPAR FOR A CONSTITUENT OF FERTILIZER.

It is said that feldspar rock, and possibly also sericite rock, in rather large quantities have been so treated as to make a small proportion of their potash soluble, and therefore available as a constituent of mixed fertilizer. Details of the process have not been published, but the feldspar is probably ground to a fine powder and mixed with raw phosphate, and the mixture is treated with sulphuric acid, as it is in the manufacture of acid phosphate. Most natural phosphate rock contains fluorine, which on being liberated is supposed to attack the feldspar and to render a part of the alkali soluble. Fluorspar may be added to increase this action. Although a considerable quantity of material was prepared in this way in 1916, it is not included in the reported production of potash salts for 1916, as little, if any, of it is believed to have been marketed during that year. The difficulty of procuring feldspar of sufficiently high content of potash, the high cost of preparing the feldspar, and the present high cost of sulphuric acid seem to make doubtful the success of a process that yields so low a percentage of soluble potash.

POTASH FROM GEORGIA SERICITE.

In April, 1916, it was announced that an experimental plant was being erected at East Point, Ga., for producing potash, presumably from feldspar and sericite.

The Pickens Mineral Co.[1] is reported to have been incorporated in January, 1916, for the purpose of operating leases on deposits of sericite in Georgia near Jasper, in Pickens County, and in Gilmer County. In June, 1916, it was announced that the American Potash Co., of Atlanta, Ga., had obtained options on large areas of land containing mica (sericite), from which it was proposed to manufacture potash.

POTASH FROM LEUCITE ROCK, LEUCITE HILLS, WYO.

The American Potash Co., with headquarters at Denver, Colo., which purposes to manufacture potash from the rock of the Leucite

[1] Manufacturers Record, May 25, 1916.

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Hills, Wyo., reported but little progress in 1916. It is said that work is held up pending the settlement of questions of title, for the mining law contains no provision for the disposal of rights to mine potash in this unusual form.

Processes by which this rock may be worked have been described by A. H. Rogers.[1] The leucite rock, which carries 8.5 to 10 per cent potash, is ground with limestone just as it is ground for making cement and is furnaced in a cement kiln. The resulting clinker is ground and leached with water to form a solution of the alkalies and alumina, which are separated as they are in the process of refining bauxite to alumina.

During 1916 it was announced that another project for producing potash from leucite had been established at Superior, Wyo., near the Leucite Hills. The project is believed to have been financed by San Francisco capitalists.

RANKIN PROCESS, SAN FRANCISCO, CAL.

A process for making the potash and alumina of feldspars soluble, which is being tested by H. D. Rankin, of San Francisco, consists in treating finely powdered feldspar with concentrated sulphuric acid in carefully measured quantity and heating the mixture in a closed vessel under a pressure of about 30 pounds. The process is supposed to be adaptable also to the recovery of metals from silicates. A plant is reported to have been constructed in San Francisco.

POTASH AS A BY-PRODUCT OF THE CEMENT AND IRON INDUSTRIES.

GENERAL FEATURES.

The production of potash as a by-product of the manufacture of hydraulic cement and of the smelting of iron has been so recently achieved that its value may not be generally appreciated. The quantity of potash lost by vaporization in cement and smelting furnaces must be immense, and now that it has been found practicable to condense and recover at least a part of this vapor the potash which may be so obtained is, by some authorities, expected to furnish a large contribution to the market even when prices become more normal.

The potash that is contained as silicate in the raw material of cement is largely volatized by the heating necessary to form the cement clinker. Sodium also is driven off in the same way. The proportion of potash in the usual cement mix is small, but in the immense volume of material treated it is very great. Anderson and Nestell,[2] in a report on an investigation of the volatilization of potash from cement material made for the Western Precipitation

[1] Rogers, A. H., The possible sources of potash in the United States: Met. and Chem. Eng., vol. 13, p. 387, June, 1915.

[2] Anderson, E., and Nestell, R. J., manuscript report, referred to by courtesy of the company.

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Co., give the following representative analyses showing the percentages of potash in calcined cement mixes:

Potash in calcined cement mixes.

Cement mill.	Location.	Percentage of K_2O.	Cement mill.	Location.	Percentage of K_2O.
Alpha	Cementon, N. Y.	1.00	Pacific	Cement, Cal.	0.85
Atlas	Northampton, Pa.	1.21	Utah	Salt Lake City, Utah	1.44
Asano	Moji, Japan	.90	Riverside	Crestmore, Cal.	.80
Dexter	Nazareth, Pa.	1.33	Santa Cruz	Davenport, Cal.	1.24
Olympic	Bellingham, Wash.	.61			

As the material is fed to the kiln, a part of the finer dust is carried off with the gases of combustion, and as the gases cool the volatilized potash and soda condense in the form of a fine fume. Thus the heavy dust, which settles first, is essentially partly calcined raw material, and the finer dust, which is carried farther and cooled more, contains additional varying quantities of the alkali salts, usually sulphates. The methods of collecting and treating the dust at several plants are described under the next headings.

RIVERSIDE PORTLAND CEMENT CO., RIVERSIDE, CAL.[1]

The first cement plant that made potash as a by-product from kiln dust is that of the Riverside Portland Cement Co., of Los Angeles, Cal. This plant consists of 12 kilns. According to the system first established 11 of these kilns discharged their dust and gases into the general electrical dust-collecting system. All this dust was burned in kiln No. 12, which discharged its gases into a separate electrical treater. The dust collected when the kiln was operating on normal material formed about 99 per cent of the total solids carried in the gases. The potash is about 0.5 per cent of the raw mix, but the proportion varies somewhat according to the part of the quarry from which the rock is taken. About 90 per cent of the potash is recovered. As the general treating system did not supply sufficient dust to permit kiln No. 12 to be operated exclusively upon dust, the remainder of the charge was made up of ordinary raw mix, so that the percentage of potash in the final dust collected from kiln No. 12 varied greatly, depending on the proportion of treater dust to raw mix burned in this kiln. For a time at the outset a large accumulation of dust carrying about 2 per cent of potash was treated alone, and during this time 3 or 4 tons of dust carrying 20 to 23 per cent of potash was recovered daily in kiln No. 12. Later the normal potash content of the dust caught in kiln No. 12 was reduced to about 10 per cent.

As the kilns are fed at the end from which the draft goes out, the dust carried out of the kilns by the draft is largely ordinary cement mix about half calcined. This dust in the general treating system at Riverside is exceedingly fine, about 90 per cent of it passing the

[1] Abstracted from a report by J. V. Reymond to the Western Precipitation Co., Los Angeles, Cal., by courtesy of the company.

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200-mesh sieve. The potash in the "clay" (which is really a rotten granitic rock containing undecomposed feldspar) is a silicate which is freed by the burning and combines with sulphurous gases to form sulphate of potash. The sulphur is derived from the fuel oil, which carries a little over 1 per cent. Nearly the entire potash content of the dust is soluble in water as potassium sulphate.

In subsequent operations the richer and the leaner potash-bearing dusts obtained from different parts of the treating system were separated, the dust carrying 10 per cent of potash or more being sold and the leaner material being returned for reburning. Finally, however, a leaching system was installed for preparing high-grade potash salts. The dust is now being leached with hot water to form a solution from which an 80 per cent potassium sulphate is separated by crystallization.

SECURITY CEMENT & LIME CO., HAGERSTOWN, MD.

A timely account of the developments in 1916 at the plant of the Security Cement & Lime Co., at Hagerstown, Md., is given by A. C. Hewett[1] in an article which is abstracted below.

The great nuisance in the manufacture of Portland cement has been converted into an industrial asset by the Cottrell fume-precipitation process. The operation of a potash plant in conjunction with the cement mill of the Security Cement & Lime Co. has indirectly increased the production of cement clinker and has been the means of economizing fuel, for the greatest recovery of potash has proved to be coincident with the greatest production of the best burned clinker, a fact that augurs well for the future of this new feature of the cement industry.

The Cottrell process of dust precipitation is very simple in theory but presents some difficulties in practice. The scheme is simply to pass the dust-laden gases through an intense electrostatic field, in which the dust becomes charged with electrical energy and is driven to one pole or the other of the field, where it accumulates and is periodically collected.

Late in 1915 experiments, tests, and analyses were begun at the Security Cement & Lime Co. plant at Hagerstown to determine what might be saved in this dust. After the preliminary work was done a representative of the company visited Riverside, Cal., where dust was already being collected. Although plans were not completed at once the contracts and construction were hastened as much as possible and a trial run of the first unit was commenced June 15, 1916. Three other units were completed by the middle of July.

The treaters that collected the dust are attached to the old stacks, through which the dust formerly passed into the open air. The furnace gases are drawn through electrode pipes fitted with a central carefully insulated wire, the pipe and the wire forming the two poles of a high-tension electrical field when the treater is in operation. The current used is stepped up in a transformer to 70,000 volts and is turned off from time to time when the pipes are rapped by mechanical hammers to shake down the dust. The dust is col-

[1] Eng. News, Dec. 28, 1916.

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lected in the lower hoppers of the steel-treater structure and is drawn off regularly into burlap bags, each containing about 100 pounds.

Late in 1916 two kilns measuring 7 by 100 feet and three kilns measuring 8 by 125 feet were producing every 24 hours 20 to 25 short tons of dust, containing 5 to 10 per cent pure potash (K_2O), which is equivalent to 10 to 20 per cent potassium sulphate. This dust is very fine and is highly desirable for use as fertilizer. It is advertised as Security potash treater dust, and has been successfully used by some of the largest manufacturers of fertilizer since July, 1916.

Analysis of Security potash treater dust.

Potassium sulphate	16.7
Potassium oxide (combined as silicate)	3.3
Sodium chloride	4.0
Calcium carbonate, sulphate, and oxide	52.0
Silica	15.0
Alumina	6.0
Iron oxide	3.0
	100.0

Water-soluble potash (K_2O) as sulphate, 9 per cent; slowly soluble potash (K_2O) as silicates, 3.3 per cent.

The production reported for 1916 represents only about half a year's work and was diminished by the vicissitudes incident to starting a new project. The operation is considered successful, and further experience will undoubtedly enable a more precise adjustment of conditions to give the maximum practicable output.

BUFFALO POTASH & CEMENT CORPORATION, BUFFALO, N. Y.[1]

The Buffalo Potash & Cement Corporation, organized to extract potash from feldspar and similar rocks and to manufacture cement by the same process, uses the Brown process, which is covered by United States patents Nos. 1123841 and 1123964. This corporation experimented at Catasauqua, Pa., for several months at the plant of the Catasauqua Castings Co. before establishing the plant at Buffalo. The charge was furnaced in a foundry cupola and the gases were led from the top of the furnace to an electric precipitator, in which the potash salts were collected, the gases then passing through a fan to the open air.

The present plant is on the water front at Buffalo, near the plant of the Buffalo Union Furnace Co., where it obtains cheap water transportation over the Great Lakes for raw materials and finished products. The plant has a floor space of 24,800 square feet, and covers about 4 acres.

The company owns 90 acres of land on Georgian Bay, carrying, according to report, large deposits of high-grade feldspar containing an average of 10 per cent of potash. A supply of limestone of exceptionally high grade, available to water transportation, is also said to be assured at a satisfactory price by the Michigan Limestone & Chemical Co.

[1] Abstract from a report by J. V. Reymond to the Western Precipitation Co., Los Angeles, Cal.; A potash plant at Buffalo: Iron Age, June 29, 1916; Potash manufacture at Buffalo: Iron Age, July 13, 1916; also a prospectus issued by the company.

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It is claimed that the process gives two products—potash and cement—at practically the cost of one. Limestone, feldspar, and calcium chloride are charged into a water-jacketed blast furnace of the standard copper-smelting type and are fused by burning coke. Potassium chloride is given off as a vapor, which condenses or sublimes on cooling, and from this sublimate the finished product is to be derived by dust collectors and a gas washer. The molten material containing the necessary ingredients in proper proportions for cement is tapped out at the bottom of the furnace, granulated, and ground into cement.

ALPHA PORTLAND CEMENT CO., ALSEN, N. Y.

Steps for collecting cement dust have been taken by the Alpha Portland Cement Co. at their mill No. 6, at Alsen, N. Y. At the close of 1916 it has been decided to erect a Cottrell electric precipitation plant, and it is expected that the dust collected will make a valuable fertilizer.

SOUTHWESTERN PORTLAND CEMENT CO., VICTORVILLE, CAL.

By means of big settling chambers the Southwestern Portland Cement Co., at Victorville, Cal., is recovering dust which is reburned for cement, but the company's report for 1916 stated that no steps had been taken to recover or utilize the potash in the dust.

BETHLEHEM STEEL CO., SOUTH BETHLEHEM, PA.

Probably the Bethlehem Steel Co. first collected and sold blast-furnace dust for its content of potash. This work is discussed in a very comprehensive and adequate way by R. J. Wysor[1] in a paper that is by far the most valuable contribution regarding the blast-furnace possibilities that has yet appeared.

The iron blast-furnace procedure may be briefly described as follows: Iron ore, coke, and limestone are charged into the furnace, ignited, and subjected to a blast of heated air. The gases from the furnace, which are not completely oxidized, are first cleaned in dust-collecting chambers and washing towers, where they pass through a spray of water. They then go to "stoves," where they are burned and drawn through the openings in a checkerwork of brick, so that the brick are heated, and by later turning the blast draft through these brick it is heated before passing to the furnace. By using duplicate sets of stoves the process is made continuous, the bricks in one set being heated while those in the other set are used for heating the air. A part of the gas is burned under boilers to raise steam for generating power.

All the raw material that enters the furnace contains a certain amount of potash, actually a very small percentage, though the aggre-

[1] Wysor, R. J., Potash as a by-product from the blast furnace: Am. Inst. Min. Eng. Bull., January, 1916, pp. 1–82; also Eng. and Min. Jour., vol. 103, p. 176, 1917.

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gate quantity is large. Mr. Wysor calculates that in the Bethlehem plant 22.4 pounds of potash are charged into the furnace for each ton of pig iron produced. Eighty per cent of this potash is volatilized in the furnace and passes out with the gases, the remainder going into the slag. A small quantity of potash is retained in the dust-settling chambers, largely as fine particles of the raw material charged. The washing of the hot gases by water apparently condenses and collects a considerable part of the potash they carry, and as this is in a large excess of water and not yet shown to be recoverable, more than half that contained in the original furnace charge is lost. As the gases are consumed in the stoves and in the steam boilers their fuel value is utilized. In these a small part of the potash still held in the gases settles out, and this is a part of that which has thus far been commercially recovered. In quantity it represents only three-tenths of a pound of potash of the original 22.4 pounds charged for each ton of pig iron produced. About 2.6 pounds of potash is carried on farther by the gases and, passing into the open air, is finally lost. The saving thus far made, though it is appreciable and may be considered almost clear profit, represents less than 2 per cent of the total potash charged into the furnace. The potash lost in the slag, around the shell, and from the top of the furnace is lost beyond practical recovery. The greater part of the soluble potash in the flue dust obtained in the dust catchers could be recovered by leaching in water, but the percentage is too low to justify its recovery in this way. The potash now lost in the wet washers and from stove and boiler-house stacks, however, may be recoverable, and as this probably amounts to about two-thirds of the potash contained in the original charge it offers a promising field for recovery. Possibly the dust might be collected from the gases before they enter the washers, where, if the temperature be reduced sufficiently to condense the potash fume, much of the fume and dust might be removed without interfering with the operation of the furnace.

In conclusion, it may be repeated that the potash-bearing flue dust marketed to date is merely the dust that settles in stoves and boiler flues, where the blast-furnace gases are finally consumed. It is a very fine, light-colored dust which is cleaned out at intervals of three or four months. In the boiler houses the dust accumulates in the combustion chambers, in the passes, and in small quantity in the horizontal flues leading to the stacks. This dust from the boiler houses is collected or cleared out frequently. Since the beginning of the war and the subsequent spectacular rise in the price of potash the Bethlehem Co. has been selling this dust at a good profit.

POTASH FROM FURNACE SLAGS.

Attention may be again called to the suggestion that the old slag dumps of lead smelters [1] may be a source of potash salts.

[1] Iles, M. W., and Shelby, C. F., Potash and soda salts from the natural decomposition of lead slags: Eng. and Min. Jour., June 3, 1899, p. 650. (Review in Soc. Chem. Ind. Jour., July 31, 1899, p. 688.)

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A salt formed by the natural decomposition of the slag in a dump at a lead-smelting works at Denver, Colo., was examined and was found to have the following composition:

Analysis of salt from slag dump from lead-smelting works at Denver, Colo.

K_2O	28.44	MnO	.26
Na_2O	13.48	Cl	.47
CaO	1.80	SO_4	48.45
MgO	1.08	Loss on ignition	2.40
Fe_2O_3	.29		

This salt probably contains 52.64 per cent of potassium sulphate and 29.97 per cent of sodium sulphate, suggesting that old slag dumps may be a source of soluble potash salts.

A report on the manufacture of potash fertilizer from steel slag, published in some of the journals, evidently confused potash with phosphate.

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——— The Bethlehem Co. saving potash as by-product in iron making: Manufacturers Rec., June 8, p. 41.

——— The blast furnace as a potash producer: Chem. Eng., vol. 23, pp. 198–200; also Chem. Abstract, p. 1914.

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Logan, T. F., Potash in iron making as viewed by Government experts: Manufacturers Rec., May 25, p. 45.

——— A potash plant at Buffalo: Iron Age, June 29.

Wysor, R. C., Potash as a by-product from the blast furnace: Am. Inst. Min. Eng. Bull., January, pp. 1–32.

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POTASH FROM KELP.

GENERAL STATEMENT.

Potash and potash fertilizer were made from kelp in 1916 by nine companies, which reported a total production of 5,315 short tons. About 50 per cent of the product was refined salts; the remainder was dried kelp, char, or ash prepared to be used as an ingredient of fertilizer, the total output aggregating 1,556 tons of potash expressed as K_2O. This is about 16 per cent of the total quantity of potash produced in the country.

All but one of the plants reporting production are on the coast of southern California. These plants represent a considerable investment of capital, the larger ones costing from several hundred thousand to between one and two million dollars. They are operating equipment that will harvest daily at least 2,500 tons of raw kelp. It is reported that these plants had harvested and treated in 1916, up to September 1, about 125,000 tons of raw kelp, which theoretically should have yielded about 10 per cent of dry kelp, or 1,500 to 2,000 tons of potash expressed as K_2O. According to later reports, two firms operating near San Diego harvested 210,596 tons of kelp between May 4 and December 25, 1916.

PRODUCERS.

The kelp plants listed below produced potash or potash products in 1916.

San Diego, Cal., and vicinity:
- Hercules Powder Co., plant at Chula Vista.
- Swift & Co., plant at foot of Seventh Street, San Diego.
- Kelp Products Co., plant at foot of Canyon Street (Point Loma), San Diego.

Long Beach, Cal., and vicinity:
- Lorned Manufacturing Co.
- Sea Products Co.
- Pacific Products Co., of California.
- National Kelp Potash Co.

Wilmington, Cal.:
- Diamond Match Co.

Bremerton, Wash:.
- National Potash & Iodine Co., plant at Fort Stanley, Wash.

OTHER PROJECTS FOR MAKING POTASH FROM KELP.

A number of other projects for making potash and by-products from kelp are now under way or were more or less actively promoted during 1916. Some of these are genuine enterprises; others may exist on paper or in name only. The companies listed below have been mentioned in the daily press or otherwise reported as under way. The work of some of these companies is described elsewhere in this chapter (pp. 150–152), but none of them reported production in 1916.

United States Government plant at Summerland, Cal.
California Chemical Co., Summerland, Cal.
United States Potash & Fertilizer Co., plant near Gaviota or Alcatraz, Cal.
Internationol Potash & Fertilizer Co., Gaviota or Point Conception, Cal.

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International Potash Co., Long Beach, Cal.
Consolidated Potash Co., Los Angeles, Cal.
Columbia Chemical Co., Los Angeles, Cal.
Southern California Fertilizer Co., Los Angeles, Cal.
The Potassium Manufacturing Corporation, El Segundo, Cal.
The Oregon Potash Co., Portland, Oreg.
Pacific Potash Products Co., Seattle, Wash.
American Kelp & Chemical Industry (Inc.), Seattle, Wash.
Washington Potash & Chemical Co., Seattle, Wash.
American Potash & Refining Co.
Southern Reduction Co., San Diego, Cal.

NATURE AND DISTRIBUTION OF KELP.

Kelp is a seaweed that grows along the coast at certain places where the bottom is rocky and the movement of the water is favorable to its growth. It consists of a "holdfast" or group of rootlike branches by which it is attached to the bottom and a long cordlike stem terminating in a pneumatocyst or float that bears the leaf, which normally floats near the surface of the water. Several large genera of kelp grow on the Pacific coast of North America. One known as *Nereocystis* occurs in scattered beds along the northern coast, reaching as far south as Point Conception. The more abundant stands south of Point Conception are largely of the genus *Macrocystis*. The kelp generally grows in large beds or groves in what are known as pure stands. It is usually found on exposed coasts where there is continual swell, the largest patches at depths of 6 to 10 fathoms. There is some intermingling of patches, but there is no intermingling of individual plants of both genera. Abundant kelp grows along the coast of Alaska and along the Pacific coast of Mexico.

Certain species of kelp contain a high percentage of potash, which they evidently absorb from sea water. The following figures by J. S. Burd[1] give a fair idea of the composition of one of the most abundant of the species, which is now being used for making fertilizer:

Average composition of the upper (harvestable) part of the kelp Macrocystis.

Condition of sample.	Moisture.	Nitrogen.	Phosphoric acid (P_2O_5).	Potash (K_2O).
1. Fresh	86.41	0.19	0.10	1.82
2. Air dried	16.00	1.18	.63	11.45
3. Water free	.....	1.41	.75	13.63

These percentages correspond closely with those recovered in actual practice in the plants in southern California.

The species mentioned grow in large masses in open water, and when cut at shallow depths below the surface the plant readily reproduces itself. Stands cut over in the spring of 1916 are said to have attained their mature growth by the close of the year and will be ready for cutting again early in 1917.

[1] Burd, J. S., The economic value of Pacific coast kelps: California Univ. Exper. Sta. Bull. 248, February, 1915.

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GATHERING OF KELP FOR POTASH OR FERTILIZER.

Kelp or seaweed was long ago not only extensively gathered, dried, and burned for use as fertilizer in Scotland, Ireland, Guernsey, and France, but potash and other salts were extracted from it. Richardson and Watts[1] state that in 1854 no less than nine establishments in the neighborhood of Glasgow were engaged in this industry, the largest of which consumed from 7,500 to 8,000 tons of kelp a year. Methods of separating the potassium chloride, sodium chloride (common salt), and potassium sulphate from the kelp are discussed in this and other early books.

PRESENT METHODS OF RECOVERING POTASH FROM KELP.

Several processes are now used in the United States for recovering potash from kelp, either as the refined salts or as a constituent of potash-bearing fertilizer. The products obtained are kelp dried and ground for use in fertilizer; ground char, or ash of kelp; and refined potash salts (potassium chloride and potassium sulphate).

The simplest of these processes is that by which kelp is dried and ground, and such kelp formed a large part of the product in 1916. In practically all these operations the kelp is harvested by cutter barges or by cutters and barges working together and is brought to a dock on the boats. It is usually chopped or macerated, lifted by some elevating and conveying device, and stored for a short time—not long enough to permit much fermentation—and is then passed directly through drying furnaces, where it loses the greater part of its water. Its composition then corresponds approximately to that of "air-dried" kelp. (See analyses on p. 146.) If some of the organic matter is burned away, the potash content may be higher.

Kelp that is dried for use as fertilizer is usually put through a grinder and reduced to a powder, which contains not only potash but phosphoric acid and organic nitrogen.

Char or ash is produced by burning dried kelp in the open air on the beach and on metal or cement floors at the larger plants. Lately, however, to avoid objectionable smoke and odors, to regulate the burning better, and to save certain by-products that are otherwise lost in the smoke, the kelp has been charred in auxiliary furnaces. Charring is preferable to complete burning for several reasons. If the temperature becomes too high in the burning, some of the potash is lost in volatilization and some becomes fixed in silicates or insoluble slags of the ash. Burning also increases the percentage of carbonate in the residue, an increase that is objectionable if the purified chloride is to be separated later. Kelp char carrying 28 or 30 per cent potash (K_2O) is ground, sacked, and sold for use as fertilizer.

The manufacture of refined potash salts from kelp involves much more complicated problems. One of the two general methods of extracting water-soluble salts from kelp—the wet method—consists of leaching the kelp by water without preliminary drying, a process assisted by the natural decomposition or fermentation which takes place if the material is allowed to stand in water. The resulting solutions are settled, filtered, and reduced by evaporation until the

[1] Treatise on acids, alkalies, and salts, vol. 1, pp. 504–538, 1867.

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salts are crystallized. This method may be operated so as to save not only the inorganic soluble constituents of the kelp but also its organic part, which seems to be a possible fruitful source of other products. The practical operation of this method involves serious difficulties in filtering the slimy solutions obtained and in regulating the many bacterial ferments produced; and the large amount of water required to leach out the salts entails considerable expense for the evaporation by which the salts are reduced to crystalline form.

The other method—the charring method—consists in leaching the salts from the kelp char or ash prepared as already described. In both methods the salts are recovered by evaporating the leaching water and are purified by fractional crystallization. This method has its advantages and disadvantages. As the ash carries a larger percentage of potash than the kelp itself, it may be leached and the resulting salts crystallized with a much smaller quantity of water. The sulphates in the solution complicate somewhat the refining of the salts. They may be separated from the solution by special treatment, and the chlorides of potash and soda may be separated by fractional crystallization.

The wet method is employed at the Hercules plant at Chula Vista, Cal., and the charring method at the Diamond Match Co.'s plant at Wilmington, Cal. Both these plants, though large, are professedly experimental, and they produced only a small quantity of refined salts in 1916. The operations of these plants are described in greater detail on pages 145–146, 148–149.

FUTURE OF THE INDUSTRY OF EXTRACTING POTASH FROM KELP.

There has been some controversy in print as to whether potash extracted from kelp can permanently compete with other domestic potash and with imported potash when prices become normal. It is estimated[1] that there are 160 square miles of commercially valuable beds of kelp on the coast of Alaska, 5 square miles on the coast of Puget Sound, and 225 square miles on the coast of southern California, a total of 390 square miles. These beds are said to produce an annual growth of 59,300,000 short tons of fresh kelp, equivalent to 2,226,000 short tons of potassium chloride, or 1,431,446 tons of potash (K_2O)—that is, the total estimated annual growth of kelp contains 2.4 per cent of potash (K_2O). Some writers[2] contend that this estimate is too large. It is said that only about one-tenth of the kelp estimated as available is being harvested in the parts of the fields now being cut. The difference between the estimated resources and the harvest is said to be due to original overestimation of the weight of the harvestable portion. This may be in part due to the death of the plants from injury during cutting and to loss and difficulties in harvesting. But even if the gross amount of kelp growing on the Pacific coast is assumed to be as great as estimated, it should be noted that much of it is not readily available to harbors where it

[1] Cameron, F. K., Potash from kelp: U. S. Dept. Agr. Bur. Soils Bull. 100, p. 31, 1915.
[2] Burd, J. S., The economic value of Pacific coast kelps: California Univ. Exper. Sta. Bull. 248, Feb., 1915. Dewey, F. P., The business aspect of the kelp proposition: Jour. Ind. and Eng. Chem., vol. 4, No. 4, p. 311, Apr., 1912. Knudsen, Henrik, Seaweed, potash, and iodine, a criticism: Jour. Ind. and Eng. Chem., vol. 4, No. 8, pp. 623–4, Aug., 1912. Crandall, W. C., An article contributed to the San Diego Union, issue of Jan. 1, 1917.

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can be handled, and that the kelp naturally grows in rocky and exposed positions which are not readily accessible to machine cutters. Many of the fields are probably not within practicable reach of ports. The actual operations are said to yield less than 2 per cent of potash in the wet kelp harvested, and this fact should be considered in any estimates of its quantity as well as in harvesting and working it.

A recent report[1] contains the following statement:

> Notwithstanding this comparatively rapid development in the kelp industry, the problem of extracting potash from kelp commercially has not been completely solved. It is essential that methods be devised for producing the numerous by-products which can be obtained from kelp. The plants now in operation, for the most part, are engaged only in the extraction of potash. Owing to the present abnormal prices for this material, they are devoting relatively little attention to the elaboration of processes for the recovery of by-products. If this situation continues, they probably will not be able to produce potash at a profit when conditions become normal. In the circumstances, it seems desirable for the Department [of Agriculture] to demonstrate the commercial feasibility of producing potash and by-products from kelp with a view to putting the industry on a sound economic basis.

By adopting Burd's estimates of the constituents of kelp (p. 141), giving a normal market value of about $3 a unit (1 per cent per ton) for the nitrogen and 75 cents a unit for the potash, air-dried kelp is seen to be worth about $12 a short ton at the point of manufacture. As about 6.2 tons of fresh *Macrocystis* will yield 1 ton of dried kelp it seems that dried kelp can be used as a fertilizer if 6.2 tons of wet kelp can be harvested, dried, ground, and packed for $12 with reasonable profit. The price of potash is now $3 or more a unit, so that the margin for profit is very great, the price per ton being temporarily increased from $12 to $45.50 or more. It is therefore easy to see why the industry may flourish under present conditions and to realize the difficulties it may meet when the market becomes more nearly normal. Somewhat the same mode of computation may be applied to the manufacture of the products of higher grade, but the calculation then becomes much more complicated.

PLANTS IN OPERATION.

GENERAL CONDITIONS.

The projects for the recovery of potash from kelp, as from other sources, deserve every legitimate encouragement possible from National, State, and local governments. Although not established primarily for public or patriotic ends, these projects nevertheless aim to supply a commodity that is much needed in manufacturing industries and in agriculture—a commodity that the country might urgently need in time of emergency. Security as to a domestic source of such a supply is worth some sacrifice both by certain companies that are peculiarly dependent on these materials and by the nation. For this reason, if for no other, the public is entitled to a certain amount of information regarding the work done by these enterprises. The collection of this information need not involve prying into trade secrets nor any activity that might lead to patent interferences or the like, but nevertheless general features of the industry should be made known, and any difficulties met should be reasonably discussed in

[1] Report of the Secretary of Agriculture, Nov. 15, 1916, p. 34.

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order to promote a broader understanding of the commercial possibilities. Most of the manufacturers admit the justice and propriety of these statements, and the writer desires to acknowledge the courtesy extended to him at nearly every plant he visited and the generous assistance given to him while he was gathering the data on which the following general statement of the industry is based.

HERCULES POWDER CO., CHULA VISTA, CAL.

The plant of the Hercules Powder Co., which is on the shore of San Diego Bay between Chula Vista and National City, about 7 miles south of San Diego, began to make potash salts in August, 1916. The company's intention to build this plant was announced in the fertilizer journals in February, 1916. The buildings, digester tanks, and other equipment of this extensive plant cover 30 to 40 acres and undoubtedly represent the largest investment made in this industry during the year.

This project is designed to make potash salts and acetone from kelp. Both these products are needed for making explosives, and the output of the plant will probably be consumed by the powder factories of this company. The company intends, of course, ultimately to make all possible by-products.

Kelp cut from the most available beds off San Diego Harbor is brought on barges to the plant, where, after maceration and the addition of water and lime, it undergoes fermentation in a series of digester tanks having an aggregate capacity of about 12,000,000 gallons. The fermentation is so controlled by temperature and by forced aeration that the kelp is decomposed without putrefaction; acetic acid is produced by the decomposition of the cellulose and mucilaginous substances and the soluble constituents pass into the water. These constituents include potash and soda, mostly as chlorides, and the acetic acid combines with the lime to form a calcium acetate. When fermentation has been brought to the desired stage, which is reached in a week or more, it is stopped by heating the liquor to the boiling point ("sterilizing") and the coarser fragments of kelp leaf are screened out. It is hoped ultimately to utilize these screenings, which consist mainly of cellulose, but contain about 4 per cent potassium chloride (KCl). The solution passes through settling apparatus and thence into immense wooden tanks, where it stands and is further clarified for a few days. In the course of this procedure certain reagents are added, which convert the acetate into a more convenient form for handling.

The clear liquor is then drawn off, and the settlings or sludge is filtered. The solid residue from the filters is further treated to recover its potash. The liquor now contains a little more than 1 per cent of potash (K_2O) as potassium chloride (KCl) and about the same percentage of acetate as sodium acetate, in a solution that carries 4 to 5 per cent of dissolved salts. The liquor is concentrated in multiple-effect evaporators to the saturation point of some of the more soluble salts, and is passed thence for further concentration to open boiling tanks, from which it is run into crystallizers, where, by alternately hot and cold treatment, a mixture of sodium and potassium salts is crystallized out of it, most of the acetate remaining in solution. The chloride salts are then redissolved in water and

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separated and by hot and cold treatment purified by fractional crystallization until they yield a potassium chloride 90 per cent pure. This salt is dried on a centrifuge and by steam drier and is packed in 200-pound sacks for shipment.

The acetate left in the mother liquor is to be converted to acetone by a special process, but when the plant was visited in October, 1916, this part of the equipment had not reached a producing stage. The capacity of the plant has been estimated at 20 or more tons of potash salts a day.

SWIFT & CO., SAN DIEGO, CAL.

In January, 1916, newspapers announced that Swift & Co. intended to build a plant in San Diego for making potash fertilizer from kelp. The plant was completed for preliminary operation about the middle of the year and has since continuously produced ground dried kelp and ash.

The plant is a substantially built structure on the harbor front at San Diego at the foot of West F Street. According to press accounts the plant alone represents an investment of about $250,000, and an additional sum was expended for constructing a 250-foot wharf, storage bins, and other accessories. The plant consists of a battery of rotary direct-heat driers that use oil as fuel. The kelp is brought in on cutter barges and is shredded and carried by conveyor belts and troughs to the driers and thence to the grinders. The product, a dry brown powder, is then sacked and shipped. Partial analyses of the two representative samples of the product were reported to give the following results:

Analyses of powdered kelp.

Moisture.	Phosphoric acid.			Nitrogen.	Ammonium.	Potash.
	Available.	Insoluble.	Total.			
10.83	0.71	0.12	0.83	1.25	1.52	15.31
12.39	.53	.12	.62	1.19	1.45	14.26

Late in the season of 1916 the moisture in the product was reduced to about 6 per cent. A small quantity of ash produced by local burners was also handled at this plant.

This product is sent to factories in the Eastern States to be incorporated into mixed fertilizers. The plant can handle daily 100 to 350 tons of wet kelp, which yields a ground and dried product weighing about 10 per cent as much.

About the end of the year the company had the misfortune to lose one of its largest, newest, and best-equipped harvesting barges, the *Aliceil*, in a violent storm, which did much similar damage elsewhere.

KELP PRODUCTS CO., SAN DIEGO, CAL.

Another firm that made potash from kelp in 1916 was the Kelp Products Co., 132 B Street, San Diego, at its factory at the foot of Canyon Street, Point Loma. This factory is operated by E. Blanck-

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enburg, the chemist for the company, who was one of the pioneers of the kelp industry on the Pacific coast. The product is an ash carrying about 30 per cent of potash. For some time in 1916 this plant was doing experimental work for other companies, so that it made no output until late in the year.

LORNED MANUFACTURING CO., LONG BEACH, CAL.

One of the larger plants for making potash or potash fertilizer from kelp near Long Beach, Cal., is that of the Lorned Manufacturing Co., formerly known as the American Products Co., which was itself formed by the combination of the Coronado Chemical Co. and the Pacific Chemical Co., of San Francisco. The present company is reported to be a subsidiary of the Simmons Hardware Co., of St. Louis. E. J. Porteous, the chemist for the company, was early identified with the development of the kelp industry in this country.

At this plant either potassium chloride (muriate) of 95 per cent purity or ground kelp char containing 28 to 30 per cent potash (K_2O) was produced almost continuously in 1916, the greater part of the time with an average daily consumption of 100 to 200 tons of fresh kelp.

The kelp is brought in through Long Beach Harbor to the company's docks, where it is hoisted by automatic devices to storage bins and carried thence to large rotary driers, in which it is partly dried. Throughout most of the season this dried kelp was spread on a large concrete floor and burned in the open air by a slow fire. This fire was at first raked by hand to insure uniform burning, but later a rotary charring drum was installed, in which, it is said, the kelp is so burned that the smoke and gases are piped back into the plant through the driers and furnaces and consumed by reburning, thus abating the nuisance caused by smoke and odors.

Early in the season the muriate was extracted from the kelp char by leaching it with hot water and by vacuum evaporation and purification of the salts by fractional crystallization. By this means potassium chloride 95 per cent pure was obtained. Late in the season a contract was made for marketing the entire product of the plant as kelp char, which is ground to powder and sacked for shipment in the usual way.

This company has also done experimental work to discover methods of recovering by-products—such as carbon and creosote, iodine, and possible derivatives of creosote—and to devise means of utilizing them.

Just at the end of 1916 the company started to build a second plant at Summerland for making potash salts from kelp by methods similar to those employed at Long Beach.

SEA PRODUCTS CO., LONG BEACH, CAL.

The plant of the Sea Products Co. is on Long Beach Harbor adjacent to that of the Lorned Manufacturing Co. The Oceanic Engineering Corporation is allied with it but is not considered a potash-producing company, although it also operates a plant. Late in the season these plants were handling about two barge loads (200 to 400 tons) of kelp a day. This kelp was chopped, dried in a double set of

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rotary drum furnaces in each plant, and charred, most of it in the open, by burning on the ground. The second unit at the Oceanic Engineering Corporation is reported to have started operations early in September. Still later a rotary charring furnace was installed for this part of the operation and reduced the hand labor required. The char was pulverized and sacked for shipment in the usual way.

NATIONAL KELP POTASH CO., LONG BEACH, CAL.

The National Kelp Potash Co., which was incorporated early in January, 1916, is said to have leased and taken an option on a site near the head of Channel No. 2, Long Beach Harbor. Dr. S. R. Oppenheim, whose name is a familiar one in connection with the early stages of the kelp industry on the Pacific coast, was for a time identified with this plant.

The plant stands near those of the Lorned Manufacturing Co., the Sea Products Co., and the Oceanic Engineering Corporation. During the latter part of the year this plant handled about 50 tons of fresh kelp a day. At first dried and ground kelp carrying about 14 to 15 per cent potash was shipped, but later, after the installation of a special down-draft brickkiln charring furnace, the product was changed to char carrying about 30 per cent potash.

PACIFIC PRODUCTS CO. OF CALIFORNIA, LONG BEACH, CAL.

The plant of the Pacific Products Co. of California, at the foot of Water Street, on channel No. 3, Long Beach Harbor, started operation toward the end of 1916 and produced a small amount of potash. The kelp is chopped as it is gathered in order to facilitate its handling over chain conveyors in the barges and through the other stages of treatment in the plant. By these conveyors the chopped kelp is taken to and from the storage bins, where it is more finely macerated and fed directly through a chute into a rotary drum drier. After leaving the drier it is elevated by a spiral conveyor to a rotary incinerator and passed through a screener and grinder directly into sacks, when it is ready for market. The capacity of the plant is estimated at 100 tons of wet kelp a day, and each of the barges will carry 175 to 225 tons of kelp.

DIAMOND MATCH CO., WILMINGTON, CAL.

The Diamond Match Co. is conducting three separate projects for producing potash salts as a source of the chlorate needed for making matches. These are the plant at Wilmington, Cal., between San Pedro and Long Beach, where the raw material is kelp; the plant at Grants, Utah, at the south end of Great Salt Lake, where a refined potash salt and possibly other products are to be recovered from the water of Great Salt Lake; and a plant at Lawrence, Mass., where experiments are being made to recover potash from suint, or wool washings. Potash salts of very high grade are needed for making chlorate, a special requirement being the elimination of sulphate.

The company's intention to build the plant at Wilmington, Cal., was announced in February, 1916. When visited in October, 1916, the plant was in experimental operation and was making 80 per cent

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muriate at a rate of about 2 carloads a month. The plant is east or Wilmington, about in eastern extension of East First Street, in the marshes near the channel of the bay known as East Basin. It stands just below the main line of the Southern Pacific Railway but is connected with the Salt Lake route by a spur track that runs around the end of the bay. The company's tract consists of about 2 acres, and is well covered with factory buildings constructed of corrugated metal. The investment here represents about $250,000.

The kelp is dried and charred in two rotary driers. Charring is preferred to actual burning, because the salts in burned kelp contain more carbonate, which makes their separation more difficult. The solution obtained by leaching the char is treated in a tall building at the south end of the group, the treatment starting at the top and working down step by step. The solutions are filtered in standard filter presses and treated hot and cold for the separation of sodium and potassium chlorides from the sulphates, the evaporation being by artificial heat in open pans, no vacuum apparatus being employed. The potassium chloride and the sodium chloride are separated from the sulphates by a special process. Iodides may be considered by-products and may be utilized later.

The plant is still in an experimental stage, subject to modifications of equipment and procedure. According to an official statement made by the company it does not expect that the potash made at this plant will compete in price with German muriate of potash when importation from Germany is resumed, and in the company's accounts the cost of this plant has therefore been charged to operating expenses.

NATIONAL POTASH & IODINE CO., BREMERTON, WASH.

The National Potash & Iodine Co., of Bremerton, Wash., produced a small quantity of fertilizer material from kelp in 1916.

MISCELLANEOUS PRODUCERS.

The San Diego Kelp Ash Co., of San Diego, and other independent burners working along the beaches doubtless added a considerable quantity to the production. It is stated in newspaper articles that altogether these independent workers prepare about 200 tons of ash a month for shipment, but as accurate statistics concerning their output are not available, it may not be accurately represented by these figures. The following article concerning this phase of the production is taken from the Los Angeles Times of January 1, 1917:

> The San Diego Kelp Ash Co. * * * has built up the independent kelp workers' business. The company in many cases furnished the money for the equipment of the kelp camps and has conducted experiments to discover the best way of handling the product.
>
> The camps employ from two to six men and are dotted all along the coast from San Diego south to Lower California. These camps are at Roseville, where about 3 acres are covered with upstanding railroad ties, between which wire is stretched on which to hang the wet kelp; at North Island, Pacific Beach, Imperial Beach, and in Lower California.
>
> There are five camps at San Martin, San Sal, Todos Santos, and other places in Lower California, where Japanese gather the kelp. Here it is burned on the rocks of the coast. Recently the Japanese have been forced to stop operation by Gov. Cantu, of Lower California, who would not permit kelp gathering without a concession.

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The makeshifts of the kelp gatherers for apparatus are interesting. Many of these men simply cut the kelp with big knives as they lean over the water from rowboats. One rakes the kelp in with a great hook and the other cuts. Some merely gather up the loose kelp that escapes from the big harvesters or is loose on the water. Most any system is in vogue among the kelp workers that will bring in the seaweed and dry it. A sea sled was invented by one of these men to harvest the kelp. This was a bottomless sled-shaped frame, which had a bar with the cutter. The kelp was scooped up within the hollow frame and put on a barge. Sleds are also used to pack the wet kelp from the shore to the drying places, for a sled is better than a wagon.

At one camp at Pacific Beach two men do a good business with a $10 outfit. The loose kelp is gathered in on an old cot bed and sun dried, then burned in a crude brick oven. The clinkers drop through from the oven and are then spread on a fusing table of bricks, where they become disintegrated by the air. The ash is sacked and taken to the ash kelp company for shipment.

ESTABLISHMENTS NOT OPERATING IN 1916.

EXPERIMENTAL PLANT OF THE UNITED STATES DEPARTMENT OF AGRICULTURE AT SUMMERLAND, CAL.

In accordance with an appropriation granting $175,000 to the Department of Agriculture a plant is being constructed for experimentation with kelp and kelp products. A site was selected at Summerland, Santa Barbara County, Cal., near the end of 1916, and bids for construction were invited. The plans cover an equipment to handle daily at least 200 tons of wet kelp, which will doubtless be treated by distillation and other methods with a special view to recover valuable by-products.

CALIFORNIA CHEMICAL CO., SUMMERLAND, CAL.

According to numerous notices in the press, dating from late in November, 1916, the California Chemical Co. acquired property and commenced to erect a potash plant at Summerland. The reports state that the company obtained a lease on what is known as the Becker wharf for docking the boats. A small tramway is to convey the kelp from the boats to the plant. The reported capitalization is $100,000.

Announcement was made in the local press on December 16, 1916, that permits to cut kelp off Santa Barbara County had been granted to the California Chemical Co., the Lorned Manufacturing Co., the United States Potash & Fertilizer Co., and the United States Department of Agriculture.

UNITED STATES POTASH AND FERTILIZER CO., ALCATRAZ, CAL.

Press reports state that the first license issued by Santa Barbara County to cut kelp under the new county kelp ordinance was granted December 22, 1916, to the United States Potash & Fertilizer Co., whose plant is to be built near Alcatraz. The license runs for 10 years but is subject to certain conditions. It is stated that the company will be permitted to cut kelp in a district near Gaviota.

INTERNATIONAL POTASH PROPERTIES, LONG BEACH, CAL.

The intention of the International Potash Properties to build a plant for working kelp on Channel No. 2, Long Beach Harbor, was

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announced in the press late in 1916. Some delay is reported in patenting a special process to be used by this company for producing a 75 per cent muriate of potash.

LORNED MANUFACTURING CO., SUMMERLAND, CAL.

At the end of 1916 the Lorned Manufacturing Co. (see p. 147) had made arrangements to start at once the construction of a second potash plant at Summerland, Cal.

KELP PROJECTS OF THE NORTHERN PACIFIC COAST.

Besides the National Potash & Iodine Co., which is listed among the producers of potash from kelp in 1916, many other projects on the northern Pacific coast of the United States have been mentioned, but little information is available concerning them. The companies known are listed below:

Oregon Potash Co., Portland, Oreg.
Pacific Potash Products Co., 95 Yesler Way, Seattle, Wash.
Pacific Potash Co., San Francisco, Cal. (Out of business.)
American Kelp & Chemical Industry (Inc.), Seattle, Wash.
Washington Potash & Chemical Co., Seattle, Wash.

CANADIAN PROJECTS FOR MAKING POTASH FROM KELP.

The following notes on projects for making potash from kelp along the Canadian coast have been taken from fertilizer journals and other press announcements and are reproduced here without further comment, as no special attempt has been made to verify the statements made.

The Canadian Potash & Algin Co. (Ltd.), organized in 1915, established a plant at Sidney, British Columbia, and in June, 1916, was utilizing 30 to 40 tons of raw kelp daily in making fertilizer. The product is a fine, dry powder.

The Chemical Refinery (Ltd.), a corporation controlled by a group of manufacturers from Wheeling, W. Va., will build a plant at St. Catherines, Ontario, Canada, for making chemicals, especially potash.

The Salts & Potash Co. (Ltd.), of Toronto, Canada, has been incorporated to manufacture potash, explosives, and other products.

The National Chemical Co. (Ltd.) owns a license granted by the Province of British Columbia to harvest the kelp beds of Kumshewa Inlet, Queen Charlotte Islands. This company also owns or controls several clam or fish canneries, cold-storage plants, a reduction plant, and wharves, some of which may be diverted to the kelp industry.

In 1915 the provincial legislature passed an act providing for the licensing of kelp reduction works., designed especially to encourage the industry and to protect persons or companies desiring to engage in it. The industry is under the jurisdiction of the ministry of fisheries. A license protects the operation of any reduction factory for an area extending 50 miles along the coast.

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POTASH FROM THE SARGASSO SEA.

The Manufacturers' Record of November 30, 1916, suggests that a combined seagoing barge, seaweed harvester, and potash reduction plant might work for its content of potash that great mass of floating vegetation known as the Sargasso Sea—an eddy in the North Atlantic Ocean so named from an abundant accumulation there of a kind of seaweed (*Sargassum bacciferum*), the mass of which is in places so dense as to be a serious hindrance to navigation. This mass covers a large part of the space between parallels 16° and 38° N. and is most dense between meridians 30° and 50° W.

This particular seaweed, when dried, is said to yield about 9 per cent of potash, which is not so much as that in some of the kelps of the Pacific coast. Vast quantities of this weed are said to be thrown up on the coasts of the Bahamas, the accumulation of hundreds of thousands of tons in one harbor at times making navigation almost impossible. It has been suggested that concessions might be obtained for operations on the Bahama Islands.

PUBLICATIONS ON KELP AND ITS MANUFACTURE.

1909. Balch, D. M., On the chemistry of certain algæ on the Pacific coast; Jour. Ind. and Eng. Chemistry, vol. 1, No. 12, pp. 777–778.

1912. Crandall, W. C., The kelps of the southern California coast, and other papers: 62d Cong., 2d sess., S. Doc. 190, p. 211.

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POTASH FROM ASHES OF WOOD OR PLANTS.

HISTORICAL REVIEW.

The review of the production of potash from wood ashes here given is based on old publications, little information being available as to the practices now followed. No special investigation of this minor phase of the potash industry has been made beyond systematic inquiry as to the production from this source in 1916.

The production of potash from the ashes of wood or plants is an industry that was established long ago and that flourished until about 1870, since which time its product has been largely displaced by the mineral salts of the German deposits. Potash is still made from wood ashes, however, though the product is smaller and now forms only a minor part of the world's output.

The very simplicity of the old process of obtaining potash from wood ashes accounts for its general use, and the lack of improvement in it is no doubt due to the fact that it has generally been largely an industry of the household or at best a small neighborhood industry. If wood ashes or the ashes of plants are soaked with water they yield a solution containing alkali, commonly called lye. If this solution is drained from the ashes and concentrated by evaporation it becomes sirupy and it may be dried to form a solid mass. This solution was usually evaporated in iron pots, whence the name pot ashes, or potash. The impure solid obtained by evaporation may be redissolved and filtered and crystallized to form a white product known as pearlash, which is mainly potassium carbonate.

The production of potash from ashes began by utilizing the ashes of household fires and afterward employed the ashes left by burning the timber in clearing land. Then timber was cut and burned on a large scale primarily for the ash. This form of the industry once flourished so greatly that it threatened to despoil certain regions of their timber. The production of potash from these sources was a considerable local industry in parts of Russia, Sweden, France, and other European countries and later in Canada and the United States. In Russia not only ashes from wood, but ashes from straw and from the vegetation of the steppes were used, and more recently sunflowers have been raised and burned for their high content of potash.[1] Not

[1] Chem. Trade News, Aug. 12, 1911.

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only land plants, but, as has already been noted, seaweeds were burned as a source of potash in Scotland, England, France, and elsewhere.

The proportion of potash contained in any one kind of wood or plant is not constant; different parts of a tree or plant and different plants of the same kind yield different percentages, though some plants are uniformly richer in potash than others. In general, the weight of the ash ranges from less than 1 per cent to about 5 per cent of that of the plant or wood, earth or other foreign matter being excluded, and the content of potash (K_2O) in the clean ash ranges from a small percentage to 40 per cent. It is, therefore, impracticable to quote average analyses that would be of much value, although many analyses, showing a great range in percentage of potash, have been published. (See bibliography, pp. 161–162.)

Most of the potash in plants is supposed to be contained in complex organic salts which by burning are converted largely to potassium carbonate, though, if lime be present, a part may be converted to the hydroxide on lixiviation. The ashes of highly siliceous plants, such as straw, may form potassium silicate, from which the potash can not readily be recovered. Some plants also contain chlorides and sulphates and salts of sodium.

METHOD OF EXTRACTION.

In producing potash from wood ashes, according to Richardson and Watts,[1] the ashes are treated in tubs made by sawing tar barrels in two. Each tub is fitted with a false sievelike bottom, which is covered with straw that acts as a filter, and below the false bottom is a plugged hole through which the liquor may be drawn off. These tubs are arranged in a double row, one above the other, and beneath is a row of cisterns to receive the liquor.

The ashes are sifted to free them from coal or charred wood, and are then moistened thoroughly, and the moistened mass is charged into the tubs and pressed firmly down. The mass is then covered with water, preferably hot, which slowly seeps through it. The fresh ashes are first treated with liquor already partly charged from previous leachings and, on the other hand, fresh water is used to extract the potash from nearly spent ashes, which even when finally discharged still contain some soluble potash. Thus the liquor becomes a strongly concentrated dark-brown solution. It is then evaporated over fire in pots or pans (originally chiefly in cast-iron pots). The liquor evaporates rapidly at first and is replenished from time to time to replace evaporation, until it becomes thick and sirupy and a hot portion of it will quickly solidify to a crystalline mass on cooling. No further addition is then made and it is evaporated to dryness at a moderate heat.

This crude potash, a saline mass that hardens and sticks to the pan, is broken out and used in this form, or it may be refined by redissolving, filtering, and recrystallizing to form pearlash.

In America the product obtained from the first evaporation is generally heated to redness, this treatment burning off much of the

[1] Richardson, Thomas, and Watts, Henry, Treatise on acids, alkalies, and salts, 2d ed., vol. 1, pp. 426–539, 1867.

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carbon it contains and converting it into grayish-pink compact "potashes," which are classified as "first sorts," "seconds," "thirds," and "unbrandables." In America also, it is said, lime is often added, so that a considerable part of the product is converted to caustic potash. The lime also converts some of the silicates which would otherwise be lost. This form is used in laundries and by soap makers.

PRESENT INDUSTRY.

Little information is available concerning the present status of the industry of making potash from wood ashes in foreign countries. By systematic inquiry, chiefly through correspondence, the Geological Survey has obtained the names of some 70 firms that are or have recently been manufacturing potash of this kind. The following-named 45 firms reported to the Survey their production in 1916, which amounted to about 825 tons, valued at from 7 to 70 cents a pound, the total value being about $270,000.

MAINE.

Fairfield Potash Manufacturing Co., West Benton.
G. A. Foss, Waterville, sold to Wm. Seltzer, Fairfield.

MICHIGAN.

Geo. C. Dietrick, Newberry.
Menominee Potash Co., Menominee.
Silas E. Wood, Maple Rapids, Clinton County.
Boyne City Potash Co., Boyne City.
Orson Prentice, West Branch, Ogemaw County.
Albin Johnson, Jennings.
August Schwartz, Pellston, Summit County.
Anderson Bros., Box 150, R. F. D. 1, Traverse City.
Adams & Co., Harbor Springs.
Wm. C. Burley, Munising.
Wm. T. Campbell, Trout Creek.
East Jordan Potash Co., East Jordan.
O. W. Martin, Kawkawlin, R. F. D. 6, Bay City.
John Slade, Gaylord Potash Factory, Gaylord.
C. M. Slade, Grayling Potash Factory, Grayling.
G. E. Teachman, Ithaca, Gratiot County.
John Thomas, Montrose.
James McClory, 115 Spratt Street, Alpena.
A. P. Anderson & Son, Parkdale Street, Manistee.
Louis C. Cretens, 1414 Delta Avenue, Gladstone.
R. W. Trapp, R. R. No. 1, Mount Clemens.
Peter Bloomquist, 822 Farrar Street, Cadillac.
L. F. Nylander, 820 First Avenue, Cadillac.
Herbert Streeter, Petoskey.
Baraga Potash Co. (L. J. Mapletoff), Baraga.
E. A. Thomas, 1600 North Niagara Street, Saginaw.
Isham & Isham, 722 Hammond Building, Detroit.

OHIO.

Philip Englehart, Luckey, Wood County.

WISCONSIN.

Antigo Potash Co., Antigo.
Erskine Potash Co., Washburn.
Forest County Potash Co., Soperton.
Wisconsin Potash Co., Shawano.

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Wausau Potash Factory, 111 Edwards Street, Wausau.
Joseph Hauser, Box 139, Oshkosh.
Ladysmith Potash Fertilizer Works, Ladysmith.
Henry Fagon, Merrill, Lincoln County.
Goodman Lumber Co., Goodman.
Northern Potash Co. (S. P. Bogart), Wells Street, Marinette.
J. N. Cotter, jr., Park Falls.
John Heinzkill, Appleton.
C. P. James, 217 Myron Street, Marathon.
Medford Chemical Co., Medford.

The statistics given below indicate that the industry is declining. The cause of its decline has been, of course, the abundant supply of cheap potash salts obtained from Germany and the manufacture of practically all needed forms of potassium compounds from those salts.

Potash produced from wood ashes in the United States from 1850 to 1905.[a]

Census.	Number of establishments.	Production.		Average price per pound.
		Quantity (pounds).	Value.	
1850	509	.....	$1,401,533	.....
1860	212	.....	538,550	.....
1870	105	.....	327,671	.....
1880	68	4,571,671	232,643	$0.051
1890	75	5,106,939	197,507	.039
1900	[b] 67	3,804,766	178,180	.046
1905	[b] 39	1,811,037	104,655	.058

[a] Bur. Census Bull. 92, p. 38, 1908.
[b] Includes establishments engaged primarily in the manufacture of other products.

An immense amount of mill waste—butts, slabs, and sawdust—is burned at sawmills in large incinerators and under boilers as fuel. Most of this material is doubtless burned at a heat so intense that the greater part of the potash it contains is volatilized or carried off as smoke and ash in the draft of burning, so that analysis of the ash that remains in the incinerators may not show that it would be a source of much potash. It might be, however, if the material could be profitably burned at a lower temperature or if some means could be devised for precipitating and recovering the volatilized potash.

SAGEBRUSH.

In 1916 several local projects were started for recovering the potash content of sagebrush, either as a valuable ash or a refined salt. As sagebrush grows almost everywhere in the West and must be removed from land that is to be cultivated, the idea of clearing the land and at the same time obtaining a profit from the sagebrush seems very attractive. This proposal was taken up first by local interests near Pioche, Nev., and then by others in southern Idaho, in central Utah, and near Needles, Cal. The newspapers contained accounts of these enterprises, and doubtless a few small shipments of ash were made, but on the whole these projects do not appear to have thrived.

A sample of ash from Parawan, Utah, was examined in the laboratory of the United States Geological Survey. This ash, which, according to data given with the sample, represented 2.97 per cent of

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the original wood, contained 21.05 per cent potash (K_2O). Wide variation in the potash content of the ash is reported, however, due, in part, probably to differences in the composition of the various plants, but perhaps even more to the manner of burning the wood. Sagebrush burns with strong heat, and doubtless much of its potash is volatilized in an ordinary sagebrush fire, and the resulting ash is more or less siliceous and mixed with soil, with which also some of the potash may become combined.

POTASH FROM BEET AND CANE MOLASSES AND DISTILLERY SLOP.

PROCESSES EMPLOYED.

The refuse from the manufacture of beet sugar and cane sugar, mainly waste from the distillery where the molasses is used to produce alcohol, has long been used for making potash salts or a potash-rich fertilizer. As this material is once more becoming a commercial source of potash it will be considered in some detail.

The early treatises on chemistry describe methods used for obtaining "potashes as a by-product from the manufacture of beet-root and cane sugar." These methods are said to have been employed on a large scale at Valenciennes, Lille, and Rocourt, in France, at Magdeburg and other places in Germany, and in Austria.

The sugar beet is said to yield about 1 per cent of ash, nearly half of which is potash (K_2O). This potash is mainly in the juices of the plant, and in sugar making it is consequently pressed out into the sirup. Fifty to 75 per cent of the weight of beets used for beet sugar is turned out as pulp. This pulp is now in demand as stock food, for which probably most of it is used. The last product in the manufacture of sugar is the heavy sirup known as molasses, which, though it still contains a large quantity of sugar, can not be crystalized, owing partly to its organic impurities, but chiefly to its large content of salts. Thus, most of the salts accumulate in the molasses, very little going into the sugar. About 50 per cent of the molasses, however, is sugar and the rest is about equal quantities of organic substances, salts, and water.

Alcohol is, as is well known, one of the products of the fermentation of sugar.[1] Cane sugar does not ferment with ordinary yeasts, but if "inverted" it is changed to "invert sugar," a mixture of dextrose and fructose (known as grape sugar, or glucose), and this mixture readily ferments in the presence of yeast, forming principally ethyl alcohol and carbon dioxide.

The distilleries in this country that use grain make far more alcohol than those that use molasses, but many establishments use molasses and in some of them the consumption is very large, more than 100 tons a day. A distillery using molasses starts with a crude material that is already 50 per cent sugar. The molasses is diluted and to it are added acid (which brings about the necessary "inversion"), nutrient salts, and yeast; then fermentation takes a natural course. At the end of 24 hours, when in ordinary course fermentation may be completed, a "beer" has been produced that contains about 8 per cent

[1] The writer is indebted to Mr. Arthur F. Price, of San Francisco, for the substance of this introductory statement concerning the technology of the manufacture of alcohol with particular reference to recovery of potash.

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of alcohol. The beer is pumped over to the still, where it yields up its alcohol. The residue that flows from the still is called "slop," "vinasse," "schlempe," or "dunder"—a mother liquor similar to the molasses and water fermented except that it has lost its sugar, which has been transformed to nearly equal parts of alcohol and carbon dioxide.

The composition of this slop will vary within narrow limits according to the molasses used and the quantity of water added to the mix that is to be fermented. Average samples of slop derived from molasses from a representative distillery, covering several monthly periods, contained 1.25, 1.16, 1.18, 1.09, and 1.01 per cent potash, and a sample of the slop contained 2.07 per cent mineral ash, of which 0.86 per cent of the slop or 41.54 per cent of the ash was potash (K_2O), which was equivalent to 4.73 per cent potash (K_2O) in the original molasses. The soda in the original molasses was 0.54 per cent, equivalent to 4.74 per cent of the mineral ash. The potash of this particular mineral ash was reported to be largely chloride and sulphate and only in small part carbonate.

Processes for recovering potash and other fertilizer materials from distillery slop and molasses residue have been patented and from time to time have been discussed in the technical journals of the world. Austrian technical papers describe a process by which it appears to be profitable to recover this potash even in places near the principal potash mines in the world. Twelve years ago Ginsberg[1] described a process that may resemble somewhat those now used in this country. By this process from 120 to 140 metric tons of molasses are treated daily and yield about 2,300 hectoliters of residue, which is concentrated, carbonized, and worked up into potash salts. The neutralized residue is passed through three evaporators. In one, which has a heating surface of 180 square meters, it is heated by steam; in the other two, which are smaller and which are heated by waste steam or gases to a temperature of 80°–90° C. and 60°–70° C., respectively, it is evaporated in a partial vacuum. By this evaporation the residue is concentrated in strength from 20°–22° B. to 40° B. and is next carbonized in two ovens, which require no additional fuel, the heat liberated by its combustion being utilized for raising steam. From the ovens the mass is discharged into a shaft, where it smolders awhile in small trucks and is then emptied on a floor where it burns away to an ash having the following composition:

Analysis of ash of residue from molasses.

Water	0.5 to 5.4
Potassium carbonate	56.0 to 58.0
Sodium carbonate	10.0 to 12.0
Potassium sulphate	8.0 to 10.0
Sodium sulphate	.3 to .4
Potassium chloride	6.0 to 7.0
Potassium phosphate	.4 to .6
Insoluble	10.0 to 11.0
Organic substances	1.0 to 1.5

[1] Ginsberg, J., Treatment of vinasses at the Raab spirit factory: Oesterr. Brenn.-Zeit., 1905, p. 187; Zeitschr. Spiritusind., vol. 29, p. 255, 1906 (Abstract in Soc. Chem. Ind. Jour., vol. 25, pp. 771–772, 1906).

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This ash is reduced to powder in ball mills and then lixiviated with hot dilute lye. The resulting solution is concentrated to 46°–47° B. in a vacuum pan, the potassium sulphate crystallizing out from the warm mother liquor and the potassium chloride, after the mother liquor has been cooled to 25°–30° C. The residual liquor is further concentrated to 50°–53° B. and then throws down a double carbonate of sodium and potassium, from which the potassium salt is dissolved by treatment with soda lye. On further cooling, the mother liquor deposits in succession impure potassium chloride and another crop of the double salt, which is treated as before; and on repeated concentration and cooling the liquor furnishes a 95 per cent potash.

PLANT AT NEW ORLEANS, LA.

A brief notice in the Commerce Reports[1] called attention to a project for recovering potash from distillery waste in a plant at New Orleans where molasses is used in large quantities as a source of alcohol. In this report it is estimated that 106 tons of potash is wasted daily by the 25 or more distilleries in this country that subject molasses to processes of fermentation.

One of the plants at New Orleans was later reported[2] to be producing 3,000 pounds of potash (K_2O) a day as potassium chloride. At this plant about 32,000 gallons of Cuban molasses is fermented each day, forming about 250,000 gallons of distillery slop, which is evaporated to a mass containing about 50 per cent of moisture and about 3 per cent of potash. This mass is fed into a rotary kiln, which is fired with an oil burner; but the desiccated slop soon begins to burn spontaneously and the oil is shut off, the burning being controlled more or less by regulating the access of air at the discharge end of the kiln. The ash discharged from the kiln is leached and a large part of the dust and potassium salts carried to the flue is recovered in an ordinary gas scrubber that uses water.

PLANT IN CALIFORNIA.

Early in 1916 the California newspapers and trade journals contained references to projects for recovering potash from the waste products of one or more of the large distilleries on the Pacific coast. The project which has been most generally mentioned in the newspapers does not seem to have been successful, but at least one project of this class in California is worthy of notice—the Western Grain & Sugar Products Co. at Agnew, Cal., which was one of the largest producers of potash in the country at the close of 1916. The material used is distillery refuse, mainly the residue of Hawaiian molasses and California beet-sugar molasses, and the product contains a high percentage of potash salts. Near the close of 1916 this plant was producing salts at the rate of 700 short tons a month, and as the product carries 40 per cent of potash (K_2O), its output of potash at this rate would be 3,360 tons a year. The product contains some nitrogenous matter that is available for use as fertilizer. The entire

[1] U. S. Dept. Comm. Commerce Rept. 253, Oct. 28, 1915.
[2] Data from report submitted by F. K. Cameron to Bur. Mines, 1916.

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output of the plant is now used as fertilizer, but later it may be refined for use in manufactures.

OTHER PLANTS.

During 1916 potash or potash fertilizer was produced from distillery waste at Harvey, La., near Boston, Mass., and at Bay City, Mich.

The potash obtained from molasses and from distillery waste has been an important contribution to the market, the output from these sources having exceeded that from kelp.

POTASH FROM ASHES OF YEAST OR LEES OF WINE.

Knapp[1] reports that yeast and the lees of wine were used at Valenciennes, France, for making potash, but this industry was probably not large. The settlings from the wine, a thick mud, were pressed in bags, dried, and burned with as low a heat as possible to avoid volatilizing much of the alkali and to save the ashes, which were doubtless treated in much the same way as wood ashes.

POTASH FROM BANANA STALKS.

The juice of the banana stalk contains 0.7 per cent of potash.

Composition of banana stalk.

[Analysis 1 by R. H. Ellis; 2 by Dr. A. J. Hanley, both of Leeds University, England.]

	1	2		1	2
Original stalk:			Dried stalk:		
Moisture	91.6	92.7	Ash	29.9	20.5
Dried matter	8.4	7.3	Potash	13.73	12.35
Ash	2.4	1.5	Ash: Potash	45.9	59.1
Potash	1.14	.9			

Composition of ash of banana stalk.

[R. H. Ellis, analyst.]

Silica (SiO_2)	9.61
Iron (Fe_2O_3)	.16
Alumina (Al_2O_3)	3.49
Lime (CaO)	1.69
Magnesia (MgO)	1.68
Potash (K_2O)	45.90
Soda (Na_2O)	Trace.
Sulphuric anhydride (SO_3)	2.10
Carbon dioxide (CO_2)	31.11
Chlorine (Cl)	1.52
Phosphoric anhydride (P_2O_5)	2.74
	100.00

[1] Knapp, F., Chemical technology, 1848.

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POTASH FROM RESIDUUM OF OLIVE OIL.[1]

It is stated that in Italy a residuum obtained in the manufacture of olive oil, consisting of a blackish turbid liquid deposited at the bottom of the sink under the oil presses, contains about 1.5 per cent of potash (K_2O). The volume of this liquid is about double that of the olive oil produced. By evaporation and combustion 30 to 35 pounds of ash is obtained from 100 gallons of this residuum. It is estimated that in Italy 15,000 tons of ash can be obtained from this residuum. The processes by which it is proposed to make this saving in Italy may be applicable elsewhere.

OTHER SOURCES.

The older chemical treatises refer to the burning of stems and leaves of the indigo plant in Java for their potash after the color has been extracted, and the Russian use of the ash of the stalks, hulls, and leaves of sunflowers has already been mentioned (p. 153), the seed being used for oil or food. Potash was manufactured from stems of sunflowers in northern Caucasia in 1907 to the extent of 100,000 to 120,000 tons a year.[2] Potash from the ash of bamboo cane is siliceous, but is suggested as an available source of potash in British Burma.[3] The recent abnormal demand for potash or potash-bearing material has stimulated interest in many similar sources of it. Cornstalks, banana stalks, banana peels, palmetto roots, coffee pulp, sponges, and other materials that are usually considered waste have been suggested as a source of potash. Cotton-seed hulls were formerly burned as fuel in the Southern States and the ashes were used as fertilizer, but they now command a good price as cattle food, and most of them are probably used in this way.

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[3] Chem. Trade News, vol. 45, p. 158, 1882.

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Anonymous, Am. Fertilizer, Sept. 16, pp. 48–50.

POTASH FROM GROUND TOBACCO STEMS.[1]

A small amount of high-grade potassium chloride has been made from tobacco stems, but the greater part of these stems are dried and used as a direct ingredient of mixed fertilizers. Ground and dried tobacco stems are used as a fertilizer for both their potash and their nitrogen. The stems are usually sold on what is termed the "unit" basis; that is, on their content of potash and nitrogen as determined by chemical analysis. The potash is valued according to current market quotations for sulphate of potash (German salts) and the nitrogen according to current market quotations for ammoniates ("ground tankage" and "dried blood") from Chicago packing houses. The present prices of both are, of course, abnormal.

Ground tobacco stems carry 5 to 6 per cent potash (K_2O) and are also of value in a fertilizer as a "drier" and filler. The ground stems are dried until they contain only 2 to 4 per cent of moisture, the undried stems containing about 20 per cent, and are mixed with acid phosphates or other materials to produce a so-called complete fertilizer. The dry tobacco absorbs some of the excess moisture of the other materials and thus puts the product in a good "mechanical condition."

POTASH FROM WOOL WASHINGS OR SUINT.

The first step in making woolen goods is, naturally, that of cleaning the raw wool. From 30 to 80 per cent of the raw wool received at the factory consists of dirt, fat, and mineral salts. The fat is the natural oil of the wool fiber; the mineral salts consist chiefly of dried perspiration. The fat is called the "yolk" of the wool, and the water-soluble part is known as the "suint." These impurities are separated from the fiber by "scouring," and in ordinary wool scouring the dirty washings are at many places run into streams, polluting the waters. These washings contain a considerable proportion of potash, which is combined with fatty acids so that it forms a sort of natural soap. Thorpe[2] states that 100 parts of raw wool will yield 14 to 18 parts of salts, which include about 5 parts of potassium carbonate. The salts and fatty matter are usually removed by washing the wool in warm water containing softening and solvent agents, such as potash lye and potash soaps. The product of the first washing is a dirty, grayish, milky-looking liquor, which smells like dirty

[1] Information given by Mr. Alexander Galt Robinson in personal correspondence.
[2] Thorpe, Edward, Dictionary of applied chemistry, rev. ed., vol. 4, pp. 361–362, 1913.

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soapsuds when fresh, but which after standing has a putrid ammoniacal smell.

Subsequent washings yield similar liquors, which, however, are more dilute. This liquor was formerly wasted and probably most of it still is. Methods of recovering the fat, which is a valuable by-product, have been employed and methods of recovering the potash have been devised, but they have probably not been extensively used.

By one method proposed to recover the potash, the wash liquors, after being heated by waste furnace gases, are fed into an evaporator, where they are reduced to a solid residue. This residue is passed through an incinerating chamber or furnace, where it is reduced to ash, the heat derived from the burning being returned to the evaporating pans. The ash is lixiviated and the liquor is treated similarly to that obtained by incinerating distillery waste, the salts being recovered by crystallization. As suint contains but little soda the liquor may be directly dried and calcined.

Analyses of suint or wool potash.

	1	2		1	2
K_2CO_3	71.52	74.6	Insoluble	11.98	.....
Na_2CO_3	4.96	3.7	Water	2.83	.....
K_2SO_4	2.43	3.2	K_2SiO_3	.....	8.2
KCl	5.88	9.5			
				99.65	99.2

1. Thorpe, Edward, Dictionary of applied chemistry, pp. 361–363, 1913.
2. Stabler, Herman, and Pratt, G. H., The purification of some textile and other factory wastes: U. S. Geol. Survey Water-Supply Paper 235, pp. 8–26, 1909. Mean of 5 analyses.

Both the fat and the potash may be recovered by other processes. An experimental treatment of 1,000 gallons of raw liquor at Field Head mills, Bradford, England, is said to have yielded 50 pounds of wool fat and 43 pounds of crude potash.

Investigations to prevent stream pollution by these mill wastes have been made by both the State and Federal authorities at Lawrence, Mass., and elsewhere. Few determinations of the quantity of potash in the waste liquors from scouring wool in American mills seem to be available. The estimated daily production of such liquor at five mills at Lawrence, Mass., is about 120,000 gallons. On evaporation some of these liquors are said to yield 8 to 10 per cent of residue, but the potash content of the residue is not given.

In 1916 this work was taken up by the Diamond Match Co. for the purpose of recovering potash from the waste liquors of the mills at Lawrence. This is the third project started by that company to procure a supply of potassium chlorate needed in making matches. This plant, according to the report of the company, has produced some potassium chloride and other important by-products. These experiments with "mill water" were handicapped by the discontinuance of Australian wool supplies, the domestic wool waste containing not more than one-fifth the amount of potash needed to make its recovery practicable.

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GOVERNMENT WORK ON POTASH.

The United States Geological Survey of the Department of the Interior, the Bureau of Soils of the Department of Agriculture, the Bureau of Foreign and Domestic Commerce of the Department of Commerce, and the Bureau of Mines of the Department of the Interior have made investigations and issued reports concerning the possible domestic sources of potash.

UNITED STATES GEOLOGICAL SURVEY.

SCOPE OF THE WORK.

Special authority for a search for sources of potash by the United States Geological Survey, accompanied by appropriation of funds to carry on the work, was first granted by Congress in 1911, as follows:[1]

Chapter 285.—An act making appropriations for sundry civil expenses for the fiscal year ending June thirtieth, nineteen hundred and twelve, and for other purposes.

* * * * * * *

United States Geological Survey.—For chemical and physical researches relating to the geology of the United States, including researches with a view of determining geological conditions favorable to the presence of deposits of potash salts, forty thousand dollars. * * *. [Approved Mar. 4, 1911.]

This is the fund for the maintenance of all the chemical and physical laboratory work of the Survey, only a part of it being available for research for potash. Since 1911 a similar provision has been made each year by Congress.

These investigations cover a large field and include two rather distinct kinds of work, one consisting of explorations of the possible sources of raw materials from which potash might be manufactured, and the other of the study or development of processes for recovering potash from mineral or organic sources in forms that will be commercially valuable. The Survey's work has consisted mainly of a search for minerals from which potash might be manufactured. The chemical and technologic investigations naturally fall largely to

[1] Stat. L., vol. 36, pt. 1, pp. 1256, 1418.

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private initiative, although suggestions that may prove to be of value have from time to time been made by members of the Survey, such as those offered by Hicks[1] and Wells.[2]

The Survey's exploration of raw materials has covered all the evident sources—saline deposits and brines, potash-rich minerals, such as alunite, and such silicates as feldspar, mica, leucite, and greensand. Drilling in search of buried deposits has been done in several desert basins in Nevada and at one locality in Texas, but these explorations have been necessarily few and have not yet yielded results that could be directly applied to the production of potash. Besides the investigations made in the field, investigations have also been made in the Survey's chemical laboratory, although its facilities are meager and the work on the great numbers of samples sent in for testing has occupied much of the time of the chemists.

WELL AT CLIFFSIDE, TEX.

In 1916 the United States Geological Survey bored a test well in northwestern Texas in a search for potash. This boring, which is at Cliffside, a station on the Fort Worth & Denver City Railway, 6 miles northwest of Amarillo, is only one test of many which it is desired to make in the "Red Beds" of the Southwest in the hope of finding potash in the large deposits of salt and gypsum in that region. Salt beds are found in a great structural basin that extends through northwestern Texas, western Oklahoma, eastern New Mexico, and southern Kansas. These beds have been repeatedly penetrated by the drill, but no adequate test of their salts for potash has been made and potash, even if absent in much of the field, may nevertheless be segregated in some particular part of the basin—in fact, it is theoretically likely to be so segregated. The beds that include the rock salt and gypsum in this region are of the same character and general geologic age as the formations in which potash is found in Germany. Potash may have been overlooked by drillers in Texas. Most drillers would class the ordinary potash salts as salt and alkali or brine. A few small specks containing potash have been found in samples of Texas drillings, but they indicate nothing as to the quantity available or even the existence of a valuable deposit of potash. All drilling in salt beds or salt brines, not only in Texas or Oklahoma but everywhere else, should be watched and the salt or brines should be tested for potash.

Deposits of potash have been found in the Permian in central Germany, in the Oligocene (Tertiary) in Alsace, the lower Miocene (Tertiary) in Galicia, and in the supposed Eocene or Oligocene (Tertiary) in northeastern Spain, everywhere in conjunction with beds of common salt, dolomite, and gypsum, and it would be strange if deposits of this sort were confined entirely to the salt beds of Europe. A test at one locality is by no means a test of the whole structural basin. Cliffside was selected because it is nearly in the center of such a basin, is convenient of access, and is near two wells from which

[1] Hicks, W. B., The composition of muds from Columbus Marsh, Nev.: U. S. Geol. Survey Prof. Paper 95, pp. 1–11, 1916; Evaporation of potash brines: Idem, pp. 65–72, 1916; Evaporation of brine from Searles Lake, Cal.: U. S. Geol. Survey Prof. Paper 98, pp. 1–8, 1916.

[2] Wells, R. C., Experiments on the extraction of potash from wyomingite: U. S. Geol. Survey Prof. Paper 98, pp. 37–40, 1916.

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small specimens of potash have been obtained. The Geological Survey's equipment at Cliffside was delivered in November, 1915, and drilling began on December 16. This work was carried on continuously, though it was operated "short handed" for lack of funds until February 29, 1916, when, owing to the practical exhaustion of the drilling fund, it was stopped. The well was then 363 feet deep. The upper part was cased with 168 feet of 10-inch pipe and the lower part was a 6-inch hole which had to be left without casing. The delay in the work through lack of funds during the summer of 1916 and the consequent caving of the uncased hole have resulted in considerable loss.

The equipment used had been purchased for boring in the desert deposits in the West and is probably too light for efficient use in the harder sedimentary rocks in Texas.

The following is the record attained by January 1, 1917, when a depth of 386 feet had been reached:

Section of strata from log of boring at Cliffside, Tex.

	Thickness.	Depth to base
Tecovas shale (Triassic):	*Feet.*	*Feet.*
Soil and clay, surface deposits	15	15
Clay, variegated, red, white, and bright yellow	85	100
Quartermaster formation (Permian):		
Clay, mostly red, with some nodules of lime	80	180
Dolomite; compact strata separated by a stratum of red clay	15	195
Shales, brick-red, sandy, with several strata of gypsum in lower part	65	260
Sandstone, brick-red, and red shale in alternating strata	70	330
Gypsum and red sandy clay	30	360
Sandstone and shale, predominating brick-red color	126	386

Thick beds of salt interbedded with shale, dolomite, gypsum, or anhydrite probably lie below the depth reached. Estimates based on the log of the well at Boden, or Field, 17 miles away, indicate that a great thickness of anhydrite and shale will be struck at depths of 1,500 to 1,750 feet, below which will lie more salt, anhydrite, red clay, or shale. Some water was encountered at a depth of 60 feet and a stronger flow at 130 feet. Samples tested showed no more than a trace of potash.

The intention is to test for potash the salt beds that lie from about 700 feet down. This drilling, however, will test only a single place in an area of hundreds of square miles and is therefore entirely inadequate to show the nature of the deposits that underlie the field as a whole. The recent revival of drilling for oil or water in this region, especially in western Oklahoma, suggests that the Survey might more advantageously watch and sample the drillings of others, even if the wells are not at sites that would be selected for borings for potash. In fact, in view of the small appropriation available each year—not enough to drill a single well—and of the consequent loss by delay of the work from one year to the next, it seems better to expend money in testing samples from the many wells that are being drilled for other purposes than to attempt to drill a few independent bore holes.

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BUREAU OF MINES.

The Bureau of Mines has been following closely the search for a source of potash, chiefly with the hope of its possible production as a by-product in metallurgy and mineral technology. Among the most promising sources appear to be the waste gases and dust formed in making Portland cement and in blast furnaces, and the tailings and slags from copper and lead mills and smelters, especially those where the wet treatment of these metals is in use. In some mills, perhaps, neither the metal alone nor the content of potash alone would justify treatment, but if both could be recovered in the same operation their treatment might become commercially feasible. This subject is now under investigation.

The Bureau of Mines of the Department of the Interior and the Bureau of Soils of the Department of Agriculture are cooperating in the collection of statistics to show the quantity of potash that enters the iron blast furnaces of the country in the form of iron ore, coke, and limestone, and, on the other hand, the quantity that leaves these furnaces in the form of slag, the object being to determine by the difference how much potash is now carried out in the gases and dusts and also how this potash can be saved by changes in the operation of the furnaces. The Bureau of Mines is collecting samples and data through its field engineers at the plants, and the samples are then sent to the laboratory of the Bureau of Soils in Washington for analysis to show their content of potash. When all the material is in hand it is hoped that the critical examination of it may develop a national asset in potash from this source.

The Bureau of Mines is also attempting to follow as closely as possible the processes now being devised or employed both in the laboratory and on a commercial scale to recover potash from well-known natural deposits, such as western saline lakes, alunite deposits of the Rocky Mountain region, silicate material in general, and the like.

DEPARTMENT OF AGRICULTURE.

The following statement was issued late in 1916 by the Department of Agriculture concerning the work done on potash in connection with its fertilizer investigations. The appropriation of $12,500 made in 1911 for these investigations has been followed each year by other and larger appropriations. The work done under these appropriations has dealt with three fertilizer ingredients—potash, nitrogen, and phosphates.

The potash investigation was provided for in 1916 by a special appropriation of $175,000 to construct and operate an experimental plant for extracting potash from kelp. This plant, which will be built at Summerland, Santa Barbara County, Cal., has already been mentioned.

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The department has an experimental laboratory at Arlington, Va., where the raw materials used at cement plants and in blast furnaces are analyzed to determine whether the quantity of potash now lost is large enough to warrant the expense necessary to recover it. It is also investigating methods of extracting potash from wool scourings and methods of treating alunite for its content of potash.

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FELDSPAR.

By Frank J. Katz.

INTRODUCTION.

The feldspar quarries in the United States are restricted to the eastern seaboard States and California. Important factors in the localization of feldspar mining in the New England, Middle Atlantic, and southern Appalachian States are the local abundance of feldspar deposits and the concentration of the ceramic industries about Trenton, N. J., and East Liverpool, Ohio. Potteries in California account for the exploitation of feldspar deposits in that State.

USES.

Feldspar is used principally in the manufacture of pottery, chinaware, porcelain, enamel ware, and enamel brick and tide. It is used in both the body and the glaze of ceramic products. In the body it constitutes from 10 to 35 per cent, its value there being due to the fact that it melts during firing at a temperature below the fusing points of the other ingredients and forms a firm bond between the particles of clay and quartz. In glazes and enamels from 30 to 50 per cent of feldspar is used.

Feldspar is also used as an abrasive constituent of scouring soaps and window wash. Other uses of feldspar, which do not require high-grade material, are in the manufacture of emery and corundum wheels, where it serves as a binder; in the manufacture of glass; as a poultry grit; as a constituent of roofing material; and for surfacing concrete work. Small quantities of the purest grades of potash feldspar are used in the manufacture of artificial teeth. For this purpose it brings the highest prices—$6 to $8 a barrel of 350 pounds.

The use of ground feldspar as a fertilizer has been proposed, but the results of extensive tests by the United States Department of Agriculture prove that only under special conditions is such use of value. Attempts to extract from feldspar its content of potash are still in an experimental stage. A number of patents have been taken out on processes of extraction of potash from feldspar and other potash silicates. These are summarized in the Survey report on potash salts. Other experiments have been directed toward the treatment of feldspar or other potash silicate rock in such a manner

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as to make its potash content readily soluble, the treated feldspar to be used as a fertilizer or as an ingredient of complete fertilizers. It is reported that some of the larger manufacturers of fertilizer met urgent needs for potash in 1915 and 1916 by treating feldspar with ground fluorite and sulphuric acid.

COMPOSITION AND PROPERTIES OF FELDSPAR.

The common feldspars are composed of silica, alumina, and one or more of the bases—potash, soda, and lime. There are two principal classes of feldspar—the one including potash and potash-soda varieties, the other including the soda, soda-lime, and lime varieties. The minerals orthoclase and microcline, are pure potash feldspar and though different in certain properties are chemically identical and are so considered in commerce. Their composition is $K_2O.Al_2O_3.6SiO_2$, or silica 64.7 per cent, alumina 18.4 per cent, potash 16.9 per cent. The corresponding pure soda spar is albite, $Na_2O.Al_2O_3.6SiO_2$, or silica 68.7 per cent, alumina 19.5 per cent, soda 11.8 per cent. Only the potash and soda feldspars are used and the feldspars of commerce are commonly mixtures of the two, which rarely contain more than 13 per cent K_2O. The most valuable varieties are the dominantly or nearly pure potassic or sodic feldspars. Lime feldspar is called anorthite. Its composition is $CaO.Al_2O_3.2SiO_2$, or silica 43.2 per cent, alumina 36.7 per cent, lime 20.1 per cent. Soda-lime feldspars form a continuous series of varying proportions of soda and lime. Two or more of the various feldspars may be present in the same deposit or even in the same crystal.

The principal uses of the potash and potash-soda feldspars arise from the fact that within certain ranges of temperature they melt without becoming really fluid and on cooling form strong colorless or light-colored glass. Pure soda feldspar forms similar glass, but is more fluid when melted and is therefore more desirable for some purposes and less desirable for other. Melted soda-lime feldspars, on the other hand, become more or less crystalline on cooling. Potash feldspar begins to soften at about 1,150° C., or at Seger cone 1, and is completely fused at 1,310° C (Seger cone 9). For soda feldspar the corresponding range is about 150° C., and complete fusion takes place at a somewhat lower temperature.[1]

Feldspars have a highly developed capacity to cleave on plane surfaces in two directions inclined at about 90° and show an imperfect cleavage in a third direction. This property facilitates crushing and grinding to sharp particles. The hardness of feldspar is about that of ordinary glass and therefore the mineral is more suitable for certain abrasive cleansers and polishers than harder substances commonly used.

The potash and potash-soda feldspars mined in the United States are mostly pale flesh-colored to nearly white. Some are reddish and pearly gray. Soda feldspars and soda-lime feldspars are commonly pure white or light gray and pale green in color. When finely ground all commercial feldspars are either white or very pale pink.

[1] Day, A. L., and Allen, E. T., The isomorphism and thermal properties of the feldspars: Carnegie Inst. Washington Pub. 31, pp. 13–75, 1905; also Am. Jour. Sci., 4th ser., vol. 19, pp. 93–142, 1905.

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GEOLOGY AND MINERALOGY OF FELDSPAR.

Although feldspars are among the most widely distributed minerals and are constituents of nearly all igneous rocks they mostly form grains too small and too intimately associated with other minerals to be of commercial importance. Commercially valuable feldspar usually occurs as a constituent of pegmatites—rocks of extremely coarse grain and irregular texture. In mineral composition pegmatites vary greatly, but those of present commercial importance belong chiefly to two types—(1) the granite pegmatites or "giant granites," composed essentially of feldspar, quartz, and mica, and (2) the soda pegmatites, which consist mainly of soda feldspar (albite) and small quantities of hornblende. By far the larger number of the feldspar quarries of the United States are in deposits of granite pegmatite; only a few, in southwestern Pennsylvania and adjacent parts of Maryland, are in the soda pegmatites.

In size the pegmatite masses range from short bands a few inches across to great masses half a mile in width and traceable for miles. Some of these masses are very irregular in form, but most are more or less lens-shaped and are intruded along surfaces of easiest parting in the surrounding rocks. Because of the tendency of pegmatite to follow the planes of easiest parting in the bordering rocks, it is possible in some areas to predict its occurrence beyond the visible outcrops; but all such predictions must be made with reservation, as the pegmatite is liable to pinch out or to cut irregularly across the trend of the inclosing rocks.

The granite pegmatites contain, besides feldspar, the following minerals in abundant proportions: Quartz, muscovite (white mica), biotite (black mica), and black tourmaline. Generally less abundant are garnet, magnetite, and beryl. Quartz is commonly intimately intergrown with some of the feldspar.

COMMERCIAL AVAILABILITY.

Whether it will pay to work a feldspar deposit depends chiefly on (1) its distance from railroad or navigable water; (2) freight rates to principal markets; (3) topographic situation and other factors affecting the cheapness with which the feldspar can be mined; (4) market conditions; (5) quantity and quality of material available. As the principal markets for the better grades of feldspar are the great pottery centers—Trenton, N. J., and East Liverpool, Ohio—the mines of Connecticut, Pennsylvania, and Maryland are more favorably situated than those in Maine and northern New York, and in the former States wagon hauls of 6 or 8 miles to shipping points are permissible, whereas in the latter States deposits must be much closer to the shipping point to be worked with a fair degree of profit.

The requirements of the pottery trade demand that in general the percentage of free quartz associated with the feldspar used for this purpose shall not exceed 20 per cent in the ground product, and certain potters demand a spar which is nearly pure, containing probably less than 5 per cent of free quartz. In order to be profitably

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worked in most feldspar mines between one-fourth and one-half of the total material that must be excavated should contain less than 20 per cent of free quartz. Freshness of the feldspar, though desirable, is not essential.

A factor of the utmost importance in the mining of pottery spar is the quantity of iron-bearing minerals (black mica, hornblende, garnet, black tourmaline, etc.) present and the manner in which these minerals are associated with the feldspar. The requirements of the pottery trade demand that the spar be nearly free from these minerals. In order that a deposit may be worked profitably these minerals, if present in any appreciable quantity, must be so segregated in certain portions of the deposit that they can be separated from the spar without much more hand sorting and cobbing than is necessary anyway in the separation of the highly feldspathic material from that which is highly quartzose or rich in muscovite. The presence here and there of minute flakes of white mica (muscovite) is characteristic even of the highest grades of commercial feldspar, and this mineral is not injurious except in so far as it is exceedingly difficult to pulverize the thin, flexible mica plates to a fineness equal to that required in the feldspar, and it is therefore necessary in mining to separate carefully as much of the muscovite as possible from the spar.

Recently potash feldspars have been sought as a source of potash salts and also by reason of their potash content for incorporation in so-called complete fertilizers. For such purposes the prices paid are generally less than for pottery feldspar of first and second grade, and if such use of feldspar is found practicable the quantities required will be far in excess of those heretofore annually required by the pottery industries. To supply such a demand pegmatite deposits must be of large size and very favorably located with respect to transportation facilities and market.

The requirements for extraction of potash and for use in fertilizer are a high potash content and convenience of location. The presence of quartz and of iron-bearing and other minerals in small quantities is of no significance. Both white and black mica are potash-bearing minerals and therefore not wholly undesirable.

Almost any coarse, undecomposed granite pegmatite is adapted to the manufacture of roofing materials and poultry grit, but these products command such low prices that they can be marketed only under very favorable conditions.

METHODS OF MINING.

The methods of mining feldspar are very simple. The excavations are nearly all open pits, most of them of rather irregular form, the valueless portions of the pegmatite being avoided wherever possible. In quarries where the pegmatite masses are rather flat lying and are overlain by a roof or worthless rock, short tunnels have been driven from the open pits.

In the Northeastern States the pegmatite is usually firm and undecomposed, even in the surface outcrops, and it is necessary to sink drill holes and blast out most of the material. In Pennsylvania,

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Maryland, and farther south most of the pegmatite is much decayed at the surface, and in the upper part of the deposits it can be readily excavated with picks, shovels, and crowbars.

METHODS OF MILLING.

The methods used for grinding feldspar for pottery and enamel ware are similar in a general way in all the Eastern States. At some mills the spar is first burned in kilns, which serves to fracture it and thus facilitate crushing and grinding. In most mills, however, the feldspar, just as it comes from the quarry, is broken with sledges, if necessary, and then fed into chaser mills. At two of the more recently constructed mills the spar from the quarry is broken by sledges to sizes suitable for jaw crushers and is then passed through cylindrical rotating driers, from which it drops to hoppers feeding Hardinge conical mills. The products of preliminary grinding, whether by chaser or Hardinge mills, are screened, the coarse parts are returned for recrushing and grinding, and the fines are passed to tube mills for fine grinding. For use in pottery feldspar is mostly ground fine enough to pass through a 100-mesh screen and commonly 96 to 98 per cent through a 200-mesh screen. The grinders prepare on demand various grades rated according to fineness, as "60 to 80," "100 to 120," "150 to 200," etc. Feldspar prepared for use in abrasive soaps is thoroughly ground to extreme fineness, and sometimes pneumatic dust collectors are employed in the mills to provide a supply of exceedingly fine spar for use as abrasive. Mills for grinding feldspar for poultry grit and roofing employ jaw or rotary crushers and steel rolls; the crushed product is graded by screening.

FELDSPAR MILLS.

Exclusive of those operated by feldspar consumers for grinding spar for their own use, there are mills in Eastern States operated by the following firms, who are dealers in feldspar, at the places named: Maine Feldspar Co., Auburn and Topsham, Me.; Trenton Flint & Spar Co., Cathance, Me.; Louis W. Howe, South Glastonbury, Conn.; Bedford Mining Co., Bedford, N. Y.; Pennsylvania Feldspar Co., Barnard, N. Y., and Toughkenamon, Pa.; Brandywine Summit Kaolin & Feldspar Co., Brandywine Summit, Pa.; Eureka Flint & Spar Co., Trenton, N. J.; Golding Sons Co., Trenton, N. J., Wilmington, Del., and East Liverpool, Ohio; Potters Mining & Milling Co., East Liverpool, Ohio; Newell Mining & Pulverizing Co., Newell, W. Va.; Clinchfield Products Corporation, Erwin, Tenn.

FELDSPAR LOCALITIES IN THE UNITED STATES.

Maine.—Maine is one of the principal feldspar-producing States. Commercially valuable deposits of pegmatite in Maine abound in the south-central and southwestern part of the State. There are or have recently been productive quarries in the counties of Androscoggin, Cumberland, Lincoln, Oxford, and Sagadahoc.

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New Hampshire.—Workable feldspar deposits in New Hampshire are located near Grafton Center, in Grafton County.

Vermont.—There are large deposits of high-grade feldspar in Vermont at Chester, Windsor County.

Massachusetts.—Feldspar pegmatite dikes are abundant throughout most of Massachusetts, but they have been commercially productive only near Blandford, Hampden County.

Connecticut.—Connecticut has for many years been an important feldspar-producing State. Pegmatites are abundant in parts of the Connecticut Valley and are worked in Hartford and Middlesex counties. Litchfield County and New Haven County are also feldspar producers.

New Jersey.—Pegmatites in New Jersey have not been commercially developed.

New York.—New York is an important feldspar-producing State. Pegmatite dikes are abundant in Westchester County and throughout the Adirondack region. Westchester County has long been a large producer of high-grade feldspar, and important deposits of excellent spar are worked in Fulton and Saratoga counties. Essex and Warren counties have important deposits of feldspar, and there are excellent prospects in remoter parts of Clinton, Franklin, and Morris counties.

Pennsylvania, Delaware, and Maryland.—A belt of territory extending from the vicinity of Chester southwest through Chester County, Pa., and through Harford, Baltimore, Howard, and Montgomery counties, Md., and including also a small area in northern Delaware, contains a great number of large, high-grade pegmatite dikes, which are quarried in many places and which supply a large proportion of the feldspar consumed in the United States.

Virginia, North Carolina, South Carolina, Georgia, and Alabama.—The Piedmont province in these States and much of the Appalachian Mountain province are occupied by rocks in which pegmatite dikes are widely distributed. Some of these have been worked for feldspar and many more have been developed for their content of kaolin, mica, and gem minerals; these latter give promise of supplying feldspar also. In Virginia an area in Bedford and Henry counties and another in Amelia and Prince Edward counties have been commercial producers of feldspar. In North Carolina the Spruce Pine district in Avery, Mitchell, and Yancey counties annually produces a large quantity of feldspar. The regions of Iredell, Lincoln, and Cleveland, and of Jackson, Macon, and Swain counties are particularly promising for feldspar production. In South Carolina some feldspar has been produced in the neighborhood of Pacolet, in Spartanburg County. There has been no production of feldspar in Georgia or Alabama.

Wisconsin and Michigan.—In central northern Wisconsin and upper Michigan is an area which contains abundant pegmatite dikes, from which there has so far been no commercial production.

Minnesota.—Granitic rocks in which there are some pegmatites occupy the northern counties of Minnesota and are also found in the valleys of Red and Minnesota rivers. The feldspar pegmatites in these regions have not been investigated and the value of these regions as sources of feldspar is not known.

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Missouri.—In St. Genevieve County in the Ozark regions of Missouri there are pegmatite dikes containing feldspars of good grade. There has been no commercial development in this region.

Texas.—In Llano and Burnet counties, Tex., there are pegmatite dikes which may become a source of feldspar.

South Dakota.—In the vicinity of Harney Peak, Custer County, in the Black Hills region of South Dakota, there are many pegmatite dikes. These have been mined for tin and lithium-bearing minerals and for mica but have not been worked as a source of feldspar.

Colorado.—The Rocky Mountain region of Colorado contains many pegmatite dikes which are undeveloped. Deposits in El Paso and Fremont counties have been prospected, and in Mesa County mica has been mined from a pegmatite which contains a large quantity of feldspar.

California.—Fresno, Tulare, and Monterey counties have supplied feldspar to California potteries, and small shipments have been made from Kern, Inyo, San Bernardino, and Riverside counties. There are large areas of granitic and metamorphic rock in the Sierra Nevada Mountains and in the southern coast ranges of California which contain pegmatite dikes, but there is very little information concerning their commercial availability. Probably most of them are too remote from market for any present or early future developments.

Other Western States.—Pegmatites are reported in other Western States, but without data as to their character, size, and abundance. There are possibilities for feldspar development in various areas of granitic and metamorphic rocks, if ever local markets arise.

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——— Feldspars of New England and northern Appalachian States: Bur. Mines Bull. 92, 1916.

De Schmidt, H. S., Feldspar in Canada, Canada Dept. Mines, Mines Branch, Ottawa, 1916. This recent illustrated publication describes deposits of feldspar in Canada, the United States, Australia, and European countries, and contains useful chapter on mining, preparation, and uses of feldspar and bibliography of feldspar technology.

MARKETED PRODUCTION.

The marketed production of domestic feldspar in 1916 was nearly 2 per cent less in quantity than in 1914, but greater than in any other previous year and 26 per cent greater than in 1915. The production in 1915 fell 22 per cent and 13 per cent in quantity behind 1914 and 1913, respectively, but was greater than in any other preceding year. As heretofore reported, the values of the yearly pro-

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duction have expressed the combined sales of crude and ground feldspar, and have, therefore, shown wider fluctuation than the quantities because of changes from year to year of the relative proportions first sold as crude or ground. On that basis the production in 1913 was the largest in the last decade, and the production in 1915 dropped almost to the low level of 1908 and 1909. The industry rallied markedly in 1916, making a production substantially as large as that in the best years. A fairer basis for comparison of yearly production is given in the accompanying curve, which shows the annual output, in long tons, of crude feldspar, for each of the last 10 years.

The average price for spar sold crude in 1916 was $3.34 a long ton, as compared with $3.46 in 1915 and $3.43 in 1914, the range in 1916 in prices reported to the United States Geological Survey being from $2.50 to $6. The average price of ground spar in 1916 was $9.30 a short ton, compared with $8.33 in 1915 and $8.31 in 1914, the range in 1916 in prices reported to the United States Geological Survey being from $6.40 to $15 a ton. Of the total marketed production as tabulated below, about 69 per cent was sold crude and 31 per cent ground in 1915, compared with 63 per cent and 37 per cent, respectively, in 1916. The tables, however, credit to North Carolina as crude production a certain quantity of feldspar ground in Tennessee before

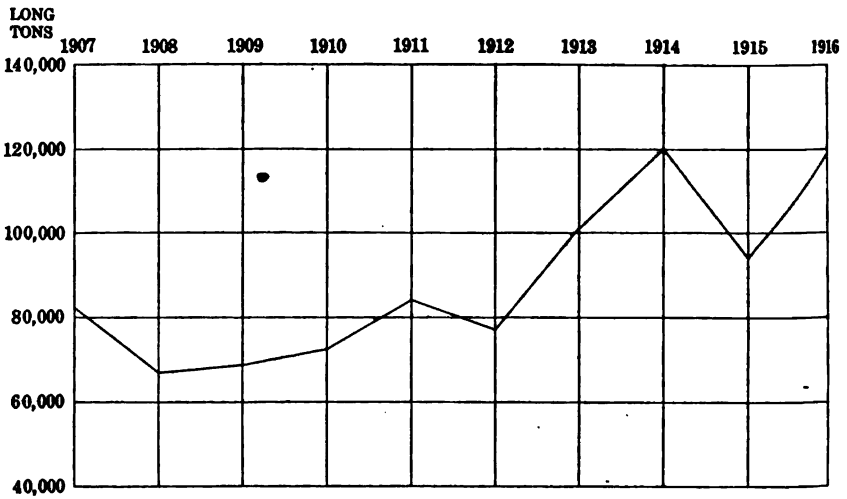

FIGURE 4.—Curve showing annual output of crude feldspar, 1907–1916, in long tons.

being sold, which materially increased the proportion of spar sold ground.

About 82 per cent of the output in 1916 was consumed in the ceramic industries. Undetermined but small quantities, probably less than 1, 2, and 3 per cent of the total quantity, were used respectively for chicken grit, in soap, and for other abrasive purposes, and in making glass. Roofing and cement surfacing accounted for about 8,000 long tons, or nearly 7 per cent of the total quantity. Seemingly, 8,000 to 10,000 long tons was used in the preparation of fertilizers and in experimental extraction of potash.

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In the report for 1915 the statistics of production of feldspar included some estimates which are here revised on the basis of more complete data. The present tabulation differs from that of 1915 by entering as sales of crude feldspar that part of the product of North Carolina that was ground in Tennessee. The following tables present classified data of production of feldspar in recent years. The first table gives, in the form heretofore followed in these reports, the sales of crude and ground feldspar by States, but because separately considered the number of producers of crude and of ground feldspar in several States is less than three, most of the data must be withheld to avoid disclosing individual production. Therefore, for better comparison of States, the data are recast, in the second table, to show the total output in each State in long tons, valued at prices prevailing in that State for crude feldspar.

Crude and ground feldspar sold in 1915 and 1916.

State.	1915		State.	1916	
	Quantity (short tons).	Value.		Quantity (short tons).	Value.
California	2,004	$9,550	California	1,400	$6,550
Connecticut	13,510	73,124	Connecticut	12,333	76,979
Maine	27,878	191,456	Maine	28,006	235,922
Maryland	12,485	36,861	Maryland	23,928	83,957
New York	17,375	65,988	New York	17,426	82,461
North Carolina, New Hampshire, Virginia	25,471	65,219	North Carolina	34,670	77,446
Pennsylvania	6,395	47,025	Pennsylvania	7,342	56,322
			Virginia, Georgia, New Hampshire, Vermont	7,576	82,640
	[a] 105,118	[a] 489,223		132,681	702,278

[a] Figures for 1915 revised in 1916.

In 1915 the total sales of crude feldspar were 65,068 long tons, valued at $215,678, and of ground feldspar 32,241 short tons, valued at $273,545. In 1916 the sales of crude feldspar amounted to 75,165 long tons, valued at $251,372, and of ground feldspar to 48,496 short tons, valued at $450,906.

Total output of feldspar in 1915 and 1916, and value at price for crude feldspar.

State.	1915		1916	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.
California	1,789	$8,362	1,250	$6,550
Connecticut	12,062	51,715	11,012	49,554
Maine	24,890	90,564	25,006	75,018
Maryland	11,147	36,861	21,364	83,957
New York	15,514	60,570	15,559	66,340
North Carolina	20,635	55,991	30,955	77,446
Pennsylvania	5,709	23,376	6,555	25,899
Virginia, Georgia,[a] New Hampshire, Vermont[a]	2,107	9,228	6,764	19,925
	93,853	336,667	118,465	404,689

[a] 1916 only.

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FELDSPAR INDUSTRY BY STATES.

The sales of feldspar in 1916 were reported from the following States named in order of their output: North Carolina, Maine, Maryland, New York, Connecticut, Pennsylvania, Georgia, Virginia, California, New Hampshire, and Vermont. Named in order of value of the product sold they were: Maine, Maryland, New York, North Carolina, Connecticut, Georgia, Pennsylvania, California, Virginia, New Hampshire, and Vermont.

California.—Four quarries—2 in Monterey County, 1 in Tulare County, and 1 in San Bernardino County—reported production in 1916. The production was smaller than in 1915, amounting to only 1,250 long tons of crude spar, valued at $6,550. Prices were $5 and $6 a ton. One carload is reported to have been "used for fertilizer," and the remainder was used in pottery.

Connecticut.—Connecticut ranked fifth in quantity and value of the production of feldspar in 1916. Three quarries were active during the year—1 in Middlesex County, 1 in Hartford County, and 1 in Windham County. The total output was 11,012 long tons of crude spar, value at $49,554, a small decrease as compared with 1915. One feldspar mill was in operation in the State throughout the year. The product was used for pottery enamel ware, tile, glass, and abrasive soaps. Large holdings of feldspar lands in the Middletown district were acquired by a company which plans to develop a process for the extraction of potash.

Delaware.—No feldspar was produced from Delaware quarries in 1916. The feldspar mill at Wilmington was in operation during the year.

Georgia.—Georgia became a feldspar-producing State for the first time in 1916. Quarries were opened at Hiram, near Atlanta, and a mill was built at West Point. Considerable quantities of ground feldspar were sold for manufacture of fertilizer at a reported price of $1.50 for each per cent of potash per ton.

Maine.—Maine ranked second in quantity and third in value as a feldspar producer in 1916. Quarries were operated near Poland and Auburn, in Androscoggin County, and near Topsham, Cathance, and Georgetown, in Sagadahoc County, and produced 25,006 long tons of crude spar, valued at $75,018. However, most of the output was sold ground by mills at Auburn, Topsham, and Cathance. The production increased in both quantity and value, as compared with 1915. Crude spar sold for $3 a long ton and ground spar for $9.50 to $10 a short ton. Deposits in Oxford and Cumberland counties were being developed. The output was used almost entirely in the manufacture of ceramics. A little was used for abrasive soaps.

Maryland.—Maryland ranked third in quantity and first in value in production of feldspar in 1916. Production was reported by 10 operators from 15 or more quarries and amounted to 21,364 long tons of crude feldspar, valued at $83,957. Prices ranged from $3.50 to $6.75 a long ton and averaged $3.93. The output was used chiefly for pottery, but considerable quantities were sold to fertilizer manufacturers.

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New Hampshire.—Feldspar was produced by one company quarrying near Grafton Center, Grafton County.

New Jersey.—New Jersey is not a feldspar-producing State, but Trenton, N. J., is an important feldspar market, in which there are mills for grinding feldspar.

New York.—New York ranked fourth in quantity and fourth in value of its output of feldspar in 1916. Four companies operated quarries in Essex, Westchester, and Saratoga counties. There were in operation during the year 2 mills in Essex County for the crushing and coarse grinding of feldspar, 1 in Westchester County for fine grinding, and 1 at Barnard, Monroe County, where feldspar imported from Canada was ground. The total production of the State for 1916 was 15,559 long tons, valued at $66,340. About 60 per cent of the product was used for roofing, concrete facings, and chicken grit, and the remainder for pottery, enamel ware, glass, and abrasive soaps. Crude pottery spar sold for $5.20 to $5.35 a long ton. Roofing spar, crushed and graded, sold for $3 and $3.50 a ton.

North Carolina.—North Carolina ranked first in quantity and second in value of the feldspar produced in 1916. Two large companies conducting three large quarry operations and many operators of small quarries, all in the Spruce Pine district in Mitchell and Yancey counties, produced 30,955 long tons of crude spar, valued at $77,446, an average price of $2.50 a ton. One company shipped its quarry product to its own mill at Erwin, Tenn. Other operators shipped to East Liverpool, Ohio, and Trenton, N. J.

Ohio.—Ohio is not a feldspar-producing State, but East Liverpool, Ohio, is an important feldspar market, in which there are mills for grinding feldspar.

Pennsylvania.—Pennsylvania ranked sixth in quantity and sixth in value as a producer of feldspar in 1916. Spar was drawn from five of the large quarries and several unlisted small ones. The total output was 6,555 long tons of crude spar, valued at $25,899, as compared with 5,709 long tons, valued at $23,376, in 1915. There were, as usual, two mills in operation in the State. The average price for crude spar was about $4 a long ton. Ground spar sold for $6.40 to $10 per short ton. Pennsylvania feldspar is used for pottery, tile, enamel ware, glass, poultry grit, roofing, and abrasive soaps.

Virginia.—Feldspar was produced in Bedford and Henry counties. It is reported that preparations are under way for extensive operations in the extraction of potash.

PRODUCTION IN OTHER COUNTRIES AND IMPORTS.

The table on page 184 gives such figures as are available on the production of feldspar in recent years in the United States and other countries. The United States imports nearly the whole of the Canadian production and none from other countries.

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Feldspar sold in principal producing countries, 1911–1916.

Country.	1911		1912		1913	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
United States	92,700	$579,008	86,572	$520,562	120,965	$776,551
Belgium [a]	.....	1,655	.....	660	(b)	(b)
Canada [c]	17,723	51,939	13,733	30,916	15,935	56,841
Germany (Bavaria) [a]	3,489	13,689	7,348	49,581	(b)	(b)
Italy [d]	39,417	44,585	37,416	44,079	35,569	39,172
Madagascar [a]	.....	.....	451	.....	(b)	(b)
Norway [e a]	38,429	124,096	43,919	146,325	(b)	(b)
Sweden [a]	39,942	89,743	37,814	88,682	(b)	(b)

Country.	1914		1915		1916	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
United States	135,419	$629,873	105,118	$489,223	132,681	$702,278
Belgium [a]	(b)	(b)	(b)	(b)	(b)	(b)
Canada [c]	18,060	70,824	15,455	59,124	(b)	(b)
Germany (Bavaria) [a]	(b)	(b)	(b)	(b)	(b)	(b)
Italy [d]	35,863	43 305	(b)	(b)	(b)	(b)
Madagascar [a]	(b)	(b)	(b)	(b)	(b)	(b)
Norway [e a]	(b)	(b)	(b)	(b)	(b)	(b)
Sweden [a]	(b)	(b)	(b)	(b)	(b)	(b)

[a] Statistics taken from Mines and quarries: General report and statistics, part 4, London.
[b] Statistics not available.
[c] Reports on mineral production of Canada, Canada Dept. Mines.
[d] Includes quartz; statistics taken from Rivista del Servizio minerario, Rome.
[e] Export figures.

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STRONTIUM.

By JAMES M. HILL.

INTRODUCTION.

For several years the known domestic deposits of strontium ores have remained undeveloped and search for crude materials carrying this metal has not been made. This general condition resulted, first, from the fact that the known deposits, though capable of producing high-grade ore, appear to have various difficulties attached to their commercial exploitation, and because, further, the market for this material was strictly limited and the value of the crude product was too small to warrant commercially the search for new deposits or the development of those already known. This latter point was particularly emphasized by the relative location of strontium deposits and chemical plants. The known deposits of commercial importance are in the Southwest and prior to 1916 the chemical plants manufacturing strontium salts were on or near the North Atlantic seaboard. Freight rates therefore were the determining factor, and foreign celestite (strontium sulphate) could be obtained at a lower cost than American ore.

Early in 1916 at least two plants[1] in southern California were making strontium nitrate, and it is understood that a third had begun operations in the fall of the year in order to take advantage of the high prices received for strontium nitrate. These plants were using ore from California and Arizona. It is reported to the Geological Survey that in the latter part of 1916 a plant in Seattle was making strontium nitrate from ore mined in Washington. On December 20, 1916, the United States consul general at London[2] reported that "strontium compounds and all mixtures containing such" had been placed on the embargo list to all destinations. The action of the British Government embarrassed the eastern manufacturers of strontium salts, and it seems probable that their stocks of ore were not so large as to outlast a long embargo.

The embargo, added to the high price of strontium salts, has had the effect of further developing the home industry not only in the mining of strontium ore but also in developing a chemical industry in which are made those salts used in night signals and fireworks. There seems little reason to doubt that there can and will shortly be developed an adequate domestic supply of strontium ore.

[1] Irvin, D. F., Strontium nitrate—a new industry: Min. and Sci. Press, vol. 113, pp. 774–776, 1916.
[2] Commerce Repts., Dec. 22, 1916.

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PRODUCTION.

From the best information available to the United States Geological Survey it would seem that approximately 250 short tons of strontium ore, of which about 4 per cent was strontianite (strontium carbonate) and the remainder celestite (strontium sulphate), was mined in the United States during 1916. This ore was mined in Arizona, California, and Washington, but not all the ore mined was sold.

As stated in the report for 1914,[1] the apparent demand for strontium ore was then about 2,000 short tons. Apparently the demand in 1916 was somewhat larger.

PRODUCTION OF STRONTIUM SALTS.

It is not possible to publish exact figures of production of strontium salts without divulging confidential information furnished the Geological Survey. Strontium nitrate was the principal salt produced, but a small output each of refined carbonate and bromide was reported. Quotations on strontium nitrate during 1916 ranged from 22 to 50 cents and averaged about 33 cents a pound. Quotations for strontium carbonate did not fluctuate as did those for the nitrate, technical carbonate being quoted in 1916 at from 16 to 18½ cents and chemically pure carbonate at 45 to 50 cents a pound.

CONSUMPTION OF STRONTIUM SALTS.

The total value of strontium salts, both imported and of domestic manufacture, consumed in the United States in 1916 was approximately $335,000—a considerable increase in value, due in part to increased price received for the products and in part to increase in quantity consumed. There can be little question that the heavy freight traffic in 1916 must have necessitated a large increase in the use of signal flares, and it seems equally certain that the use of signal lights in which strontium is employed has increased in Europe and on the high seas.

STRONTIUM ORES.

In view of the fact that 1916 saw the birth of a new and what may prove to be an important domestic chemical industry, it would seem advisable to take stock of our domestic sources of the raw material essential to this industry.

There are only two minerals containing strontium that are commercially important as raw materials in the manufacture of strontium salts and that can be called strontium ores; these are celestite, the sulphate, and strontianite, the carbonate. The carbonate is the most valuable ore of strontium, because it is soluble in weak acids and can be easily converted into the various salts; but, unfortunately, it is a relatively rare mineral, not generally found in bodies of commercial size. The sulphate is much more abundant than the carbonate and is, in fact, the principal ore of strontium. Besides these minerals

[1] Hill, J. M., Production of barytes in 1914, with a note on strontium ores and salts: U. S. Geol. Survey Mineral Resources, 1914, pt. 2, p. 66, 1915.

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there are others consisting of mixtures of calcium and barium with strontium, which can not well be used in the manufacture of pure strontium salts because of the difficulty and expense of removing the calcium and barium.

Celestite.—Strontium sulphate ($SrSO_4$) theoretically should contain 56.4 per cent strontia (SrO) and 43.6 per cent sulphur trioxide (SO_3). In nature celestite is rarely pure, containing more or less barium, calcium, and sodium. To be commercially valuable it should contain at least 90 per cent strontium sulphate, and manufacturers prefer a 95 per cent ore. The mineral, when well crystallized, looks much like barite, having nearly perfect cleavage in three directions at about right angles to one another. Like barite, it is heavy (specific gravity, 3.95 to 3.97) and can easily be scratched with a knife (hardness, 3 to 3.5). Its color is white; it has a vitreous to pearly luster; and the cleavage faces usually show a translucent bluish cast, though some celestite has a reddish cast. Typical bluish celestite crystals are characteristic of the ores found in the known localities of Michigan, New York, Ohio, Texas, Utah, and Washington.

Much of the celestite found in the Arizona and California deposits is difficult to recognize. It is a massive, finely crystalline rock, which looks something like buff-gray crystalline limestone, though it is heavier than either limestone or dolomite and contains small crystals of celestite. Its real character can be determined only by flame tests and its degree of purity only by chemical analysis. Much of the material that carries strontium in these deposits can not be considered ore, as it contains too large a proportion of impurities detrimental to the preparation of pure salts.

Strontianite.—Strontium carbonate ($SrCO_3$) theoretically should contain 70.1 per cent strontia (SrO) and 29.9 per cent carbon dioxide (CO_2). It is rather heavy (specific gravity, 3.68 to 3,714), brittle, and easily scratched by a knife (hardness, 3.5 to 4). Like the sulphate the natural ore is often impure, containing more or less calcium and barium. The typical mineral, ordinarily white, pale green, or yellow, is usually found in needle-shaped or acicular crystals commonly arranged in plumes. The deep yellowish-brown crystals found near Barstow, Cal., are excellent examples of this mode of occurrence.

Some of the specimens of strontianite from New York and Washington are pure white and consist of aggregates of small needle-shaped crystals. It is said that the Washington strontianite is evidently an alteration product of celestite, and that the principal bodies of the carbonate are found within 10 feet of the surface and are more abundant where the vein is capped by trees and moss, which suggests that organic acids may have been responsible for the alteration.[1]

TESTS FOR STRONTIUM.

There is no sure test that can be applied outside the chemical laboratory for the determination of the quality of a strontium ore. The presence of strontium is readily determined by the flame test, and although experience makes it possible to estimate roughly the proportion of impurities, no one can safely predict from a flame test what the absolute proportion of strontia will be.

[1] Private communication to the United States Geological Survey.

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Anyone equipped with a lamp which will give a hot nonluminous (blue) flame, some dilute hydrochloric (muriatic) acid, and a piece of platinum wire can make a rough test. The mineral is pulverized and heated with the acid. If the mixture bubbles (effervesces) it is in part at least carbonate, and if it goes completely into solution it is wholly carbonate. This solution should be evaporated until the liquid is a fairly thick sirup. Dip a loop of the clean platinum wire into the concentrated solution and hold in the hottest part of the blue flame. If the mineral is fairly pure the flame will be a brilliant crimson; small amounts of sodium and barium make the flame yellowish, and much barium gives a yellowish-green color to the flame. The brilliant crimson of strontium must not be confused with the duller yellowish red produced by calcium, or the purple-red flame produced by lithium.

If a blowpipe outfit is at hand, additional or confirmatory tests can be made. Both the sulphate and the carbonate, when heated before the blowpipe and placed on moistened tumeric paper, turn the latter red (alkaline reaction). The carbonate (strontianite), when heated before the blowpipe, swells and spouts, fusing only on thin edges. The sulphate (celestite), when heated, flies into pieces (decrepitates), but is fusible at a relatively low temperature into a white bead. To test for the presence of the sulphate radicle (SO_3) mix some of the powdered mineral with sodium carbonate (baking soda), powdered charcoal, and enough water to make a paste. Heat the mixture on a piece of charcoal until it melts and a little longer. Place the melt on a silver coin or piece of table silver; moisten; and if the silver turns black (owing to formation of silver sulphide), the presence of sulphur is indicated.

NOTES ON THE DEPOSITS OF STRONTIUM ORES IN THE UNITED STATES.

GENERAL FEATURES.

The following notes on the known deposits of strontium ore in the United States are in part the result of studies by geologists of the United States Geological Survey, in part taken from information supplied the Geological Survey by individuals interested in the industry, and abstracted in part from the various technical publications to which reference is given.

Celestite and strontianite are known to occur in Paleozoic dolomitic limestones in the form of linings of water courses, both large and small, as definite replacements of the constituents of the rocks near watercourses, and in veins associated with barite and calcite and galena. From what can be learned of these deposits as a group, they appear to have little commercial importance, though it is possible that at some localities bodies of celestite of size sufficient to warrant exploitation may be found. Celestite encrusted with strontianite occurs at a few places as concretions and geodes in limestones and shales of Cretaceous age. In general in this class of deposits the strontium ores are too widely scattered to warrant exploitation, but some such deposits are now being worked. The strontium deposits that appear to have the greatest promise of commercial development are closely associated with a series of sediments formed by the drying

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up of lakes of the Tertiary period. Some of these deposits appear to be due directly to evaporation of the waters, but some are known to be replacements of calcium minerals of the original formations.

STATES EAST OF MISSISSIPPI RIVER.

GENERAL DISTRIBUTION.

So far as known the deposits in the States east of Mississippi River have furnished excellent specimens of both strontianite and celestite, but have not on the whole been of commercial importance. It would, however, appear that some of this material might be hand picked at various limestone quarries in southwestern Michigan and northwestern Ohio in the vicinity of Toledo. It is known that celestite has been shipped from South Bass Island in Lake Erie. Strontia has been determined in small quantities in barite of the central Kentucky region, and celestite is reported to occur in caverns in limestone near Nashville, Tenn.

MICHIGAN.

Strontianite and celestite occur in Monroe County [1] in limestone of Silurian age. The limestone exposed in a number of quarries near Monroe, Stony Point, and Pointe Aux Peaux is extensively fissured, and both strontium-bearing minerals have been deposited in these openings apparently by circulation of meteoric water. It is said that at some quarries celestite geodes of considerable size are found which could be easily saved.

Near Rockwood, Wayne County, celestite in such quantities that it could be saved by hand picking [2] occurs in a gray dolomitic member of the Sylvania sandstone (Silurian) quarried for making glass.

NEW YORK.

Most of the New York deposits can not be considered commercial, as the strontium minerals occur in small irregular veins, replacements, or geodes in Paleozoic dolomitic limestone. A little celestite was shipped from Scoharie County years ago, but so far as known to the Geological Survey no commercial exploitation has been attempted at any of these localities in recent years.

Whitlock [3] gives notes on localities at which strontium minerals have been found in New York. Some additional information on the more important deposits will be found in the papers cited below.

Celestite has been found at the following localities:

Cayuga County.—In limestone of the Salina formation at the base of the hill on the east bank of Owasco Creek, near Auburn.[4]

Herkimer County.—Near Starkville in limestone of the Salina formation.

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[1] Sherzer, W. H., Geological report on Monroe County, Mich.: Michigan Geol. Survey Rept., vol. 7, pt. 1, pp. 85–89, 206–209, 1906.
[2] Personal communication to the writer.
[3] Whitlock, H. P., List of New York mineral localities: New York State Mus. Bull. 70, 1913.
[4] Beck, L. C., Mineralogy of New York, 1842. Dana, J. D., System of mineralogy, 5th ed.

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Jefferson County.—On High Island, in Alexandria Township; in Trenton limestone on the bank of Black River, Brownville Township; in Trenton limestone near Depauville, Clayton Township; in Trenton limestone at Chaumont Bay, Lynne Township; and associated with strontianite at contact of gneiss and limestone in Theresa Township.[1]

Monroe County.—In limestone of Niagara group at Pike quarry, near Rochester.

Niagara County.—In geodes in Lockport dolomite near Lockport.

Onondaga County.—In Salina formation near Jamesville and Syracuse.[2]

Oneida County.—Associated with strontianite in geodes in shaly limestones (probably Lockport) of Niagara group near Hamilton College, Clinton.[3]

St. Lawrence County.—In veins in limestone at the Rossie lead mines.

Schoharie County.—Strontianite is found in veins in hydraulic limestone near Schoharie courthouse.[4]

OHIO.

Celestite was found on South Bass Island, near Put-in-Bay, Ottawa County, Ohio, in 1897.[5] The discovery was made in sinking a well, the walls of which caved in and exposed a cavern lined with celestite crystals. On the floor of this cavern there was a thickness of 22 feet of celestite. The extent of the deposit was limited, the cave being in the shape of a horseshoe, 18 by 60 feet in horizontal dimensions. Tests of the surrounding limestone, though they showed it to contain a little strontium, did not indicate the presence of workable bodies of the mineral outside of the cave. Forty tons were shipped from this locality in 1897, since which time there has apparently been no further attempt to develop the deposit.

PENNSYLVANIA.

So far as known, no deposits of commercial importance containing strontium minerals are known in Pennsylvania. It is said that Klaproth,[6] a German chemist, discovered and described the mineral celestite in 1797 from some Pennsylvania specimens. The mineral is known to occur in small quantity between bedding planes of shaly limestone exposed on the west branch of Juniata River, near Bells Mills, Blair County. Strontianite has been determined in specimens obtained at Mount Union, Mifflin County.

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[1] Hough, F. B., The existing mineral locality of Lewis, Jefferson, and St. Lawrence counties, N. Y.: Am. Jour. Sci., 2d ser., vol. 9, p. 426, 1850. Also Hough, F. B., History of Jefferson County, N. Y., 1854.

[2] Krause, E. H., The occurrence of celestite near Syracuse, N. Y., and its relation to the Vermicular limestone of the Salina epoch: Am. Jour. Sci., 4th ser., vol. 18, p. 30, 1904.

[3] Root, O., A locality of carbonate of strontium: Am. Jour. Sci., 2d ser., vol. 13, p. 264, 1852.

[4] Emmons, Ebenezer, Strontianite discovered in the United States: Am. Jour. Sci., 1st ser., vol. 27, pp. 182–183, 1835. Gebbard, John, On the geology and minerals of Schoharie, N. Y.: Am. Jour. Sci., 1st ser., vol. 28, pp. 172–177, 1837. Shepard, C. U., On the strontianite of Schoharie, N. Y., with a notice of the limestone cave in the same place: Am. Jour. Sci., 1st ser., vol. 27, pp. 363–368, 1835.

[5] Pratt, J. H., Strontium ores; U. S. Geol. Survey Mineral Resources, 1901, pp. 956–957, 1902.

[6] Brown, A. P., and Ehrenfeld, Frederick, Minerals of Pennsylvania: Pennsylvania Top. and Geol. Survey Comm. Ninth Rept., p. 136, 1913.

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WEST VIRGINIA.

What may prove to be a commercial deposit of celestite near the principal markets has been described by Williams.[1] A railway cut on the west side of Knobby Mountain, in West Virginia, 4 or 5 miles south of Cumberland, Md., has exposed argillaceous Helderberg limestone carrying large crystals of celestite in lenticular cavities 1 to 3 feet long and 3 to 7 inches thick. The celestite appears to be concretionary and to be fairly concentrated in two or three different strata. The adjacent limestone beds have been replaced to some extent by celestite. Spectroscopic analysis of the celestite shows it to contain a trace of barium oxide and 0.12 per cent of calcium oxide.

STATES WEST OF MISSISSIPPI RIVER.

GENERAL DISTRIBUTION.

Strontium is known as mineralogic specimens but apparently not in commercial quantities in Brown County, Kans.; from an unnamed locality in Arkansas; in Larimer County, in El Paso County near Manitou, and on Apishap Creek, Colo.;[2] and has been reported from an unknown locality in Wyoming.

Deposits of both celestite and strontianite of commercial importance are known in Arizona, California, Texas, Utah, and Washington.

ARIZONA.

Celestite deposits 15 miles south of Gila Bend and within 2 miles of Black Rock siding on the Tucson, Cornelia & Gila Bend Railroad were operated during 1916, shipments going to strontium-salt works near Los Angeles, Cal. These deposits[3] are found on the lower slopes of a group of low isolated hills, composed of sedimentary rocks capped by a basalt flow on the north and northeast sides. The bedded deposits of conglomerate, sandstone, and gypsum strike N. 5°–20° E. and dip 45°–70° E. and are intruded by basalt in the form of dikes and sheets. The celestite-bearing beds are 40 to 50 feet thick, of which the upper 8 to 10 feet are the richest in strontium minerals. The buff to brown crystalline rock of this part of the bed shows distinct crystals of reddish or dark-brown celestite. Some of the ore is of commercial grade, but to judge from analyses of many samples much of the material contains too much calcium and barium to be suitable for the manufacture of strontium salts.

Samples of material received by the Geological Survey from deposits near Winkleman, Pinal County, and Cave Springs, Maricopa County, contain strontium but are apparently not of sufficient purity to be of commercial value.

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[1] Williams, G. H., Celestite from Mineral County, W. Va.: Am. Jour. Sci., 3d ser., vol. 39, pp. 183, 188, 1890.

[2] Smith, I. A., Colorado State Geologist Bienn. Rept. for year ending Dec. 31, 1880, p. 51, 1881; idem for year ending Dec. 31, 1882, p. 132, 1883.

[3] Phalen, W. C., Celestite deposits in California and Arizona: U. S. Geol. Survey Bull. 540, pp. 531–533, 1913.

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CALIFORNIA.

During 1916 at least two deposits of celestite and one of strontianite were developed, and a small output was shipped to eastern users of strontium ore, though the bulk of the output was used in the State.

Celestite deposits on the northeast side of the Avawatz Mountains, about 10 miles west of the Tonopah & Tidewater Railroad and about 15 miles southwest of Tecopa station, owned by the Avawatz Salt & Gypsum Co., were under development during 1916. No shipments were made pending the completion of a spur track to the property. The deposits, according to Phalen,[1] are found in lake beds that overlie a series of metamorphosed sedimentary rocks and are in turn covered with outwash gravels. The celestite lenses are found near the base of the lake beds, usually overlying a basal conglomerate, and are covered by gypsum. These beds have been folded and faulted. The celestite-bearing zone is 75 to 80 feet thick and grades into both the underlying conglomerate and the overlying gypsiferous beds. The beds richest in celestite stand out as "hogbacks," as they are more resistant to weathering than the other beds of the series. Most of the celestite is dark brown in surface exposures, but is lighter colored underground. Samples of the material indicate that some calcium and a little barium are present in much of the deposit, but ores carrying 85 to 91 per cent strontium sulphate can be obtained.

During 1916 celestite was shipped from a deposit on the Imperial-San Diego County line, about 31 miles west of Brawley, on the Southern Pacific Railroad. Information concerning this occurrence is supplied through the courtesy of Mr. David B. Roberts, one of the owners of this deposit. The celestite outcrops at the surface and lies above a very thick bed of gypsum. Analyses indicate a low content of calcium and barium and from 94 to 97 per cent strontium sulphate. It is said that ore from this deposit was used by two chemical firms near Los Angeles for the manufacture of strontium nitrate.

Strontianite has recently been found in economically important quantity 10 miles north of Barstow, Cal. According to Adolph Knopf,[2] of the United States Geological Survey,

> The first claims were staked in October, 1916, and since then nearly 40 claims have been located. They comprise a belt about 2½ miles long, situated in what are sometimes known as the Mud Hills, a name likely to be supplanted by Strontium Hills.
>
> The strontianite occurs as a replacement of limestone beds in the middle part of the Barstow formation of Merriam, of upper Miocene age.[3] This formation in the Strontium Hills has been folded into a syncline known as the Barstow syncline,[4] and strontianite has been found on both limbs of the syncline, at the same stratigraphic horizons, namely, the soft clays, shales, and limestones that form the middle of the series. The strontianite is crystallized in slender needles in radial and spherulitic groups; it is characteristically resinous in color and luster, and it is therefore spoken of locally as "rosin strontianite." The thickest body of pure spherulitic strontianite that had been discovered at the time of visit is 14 inches thick. This body is lenticular and pinches out within a few feet along the strike, although other bodies of strontianite appear at the same

[1] Phalen, W. C., op. cit., pp. 526–531.
[2] Preliminary statement for use in this chapter in Mineral Resources. A full report on these deposits is now in preparation by Mr. Knopf.
[3] Merriam, J. C. Extinct faunas of the Mohave Desert, their significance in a study of the origin and evolution of life in America: Pop. Sci. Monthly, vol. 86, p. 255, 1915.
[4] Pack, R. W., Reconnaissance of the Barstow-Kramer region, Cal.: U. S. Geol. Survey Bull. 541, p. 151, 1913.

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stratigraphic level. Beds of low-grade strontium-bearing material outcrop for hundreds of feet.

A considerable tonnage of strontianite can readily be obtained by gathering the high-grade float shed from the numerous strontiferous beds. Deep mining will be impracticable on account of the loose unconsolidated condition of the clays in which the strontiferous beds are intercalated, and all operations will necessarily be restricted to open-cut work. Seven tons of high-grade strontianite were recently shipped to a manufacturing chemist at Los Angeles to be worked up into strontium salts.

Celestite has been found in several beds in the low hills north of Lavic and Stagg stations on the Atchison, Topeka & Santa Fe Railway. According to Mallery,[1] the celestite occurs in lenses in a zone 100 feet wide lying in sedimentary rocks which dip south at steep angles. Red and yellow jasper form the foot and hanging walls of the celestite. Mallery suggests that the jasper and celestite were deposits as replacements of limestone. This is in accord with Knopf's findings of the origin of the deposits near Barstow.

TEXAS.[2]

Celestite has been recognized in Texas near Strickling, Burnet County, near Lampasas, Lampasas County, and near Austin and Mount Bonnell, Travis County. Strontianite has been recognized in the celestite areas in Lampasas and Travis counties. The strontium minerals occur as geodes and irregular nodular masses in yellow and buff argillaceous magnesium limestones of the Glen Rose limestone (Lower Cretaceous).

In 1904 about 17 tons of celestite was mined on the R. C. Walker property, in the Mount Bonnell district, since which time little more than prospecting has been done until early in 1917, when this property was reopened.

From the best information available it is inferred that the areas richest in celestite do not carry more than 10 per cent of the mineral and many deposits carry only 1 to 5 per cent. If this be the fact, considerable waste material must be moved in mining and successful operation would depend on development both of a suitable process of concentration and of a market for the output. It is certain that the Texas celestite, when properly prepared, will meet all specifications as to purity. The suggestion of Phillips [3] that the mining and washing might be carried on at spare moments and in a small way would appear to have considerable merit.

UTAH.

No celestite was sold from the deposit in Emery County, Utah, which was mentioned in the last report.[4] This deposit, 50 miles from the Denver & Rio Grande Railroad at Green River, Utah,

[1] Mallery, Willard, A discovery of celestite: Min. and Sci. Press, vol. 113, p. 952, Dec. 30, 1916.

[2] Texas Geol. Survey First Rept., p. 125, 1889; Third Rept., p. 229, 1891. Hess, F. L., Eng. and Min. Jour., vol. 88, p. 117, 1909. Hill, R. T., U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, pp. 144–147, 1901. Phalen, W. C., Celestite deposits in California and Arizona: U. S. Geol. Survey Bull. 540, pp. 524–525, 1913. Phillips, W. B., Celestite deposits in Texas: Manufacturers Rec., vol. 70, p. 53, 1916; vol. 71, p. 56, 1917. Simonds, F. W., The minerals and mineral locality of Texas; Texas Univ. Geol. Survey Bull. 5, pp. 17, 75, 1902; Texas Mineral Resources, vol. 1, p. 20, Jan., 1917.

[3] Manufacturers Rec., vol. 71, p. 56, 1917.

[4] Hill, J. M., Barytes and strontium: U. S. Geol. Survey Mineral Resources, 1915, pt. 2, p. 186, 1916.

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is said to occur in Mancos shale and is reported by Ira A. Browning, of Castle Dale, Utah, to be of commercial size.

WASHINGTON.

Celestite and strontianite are found in a vein in a low serpentine hill which outcrops a mile southwest of La Conner, Skagit County. This property has been developed by the owner, Mr. D. C. Bard, 660 Stuart Building, Seattle, Wash., who has kindly furnished the Geological Survey data relative to the deposit. It is estimated that 10,000 tons of commercial strontium-bearing material are available above the water level. The celestite is well crystallized and has the typical bluish cast of the pure mineral. The strontianite, which is said to be found in greatest abundance near the outcrop, is a finely crystalline white material. Samples received by the Geological Survey were partly analyzed by A. A. Chambers, with the following results: Celestite ($SrSO_4$), 97.03 per cent; CO_2, trace; strontianite ($SrCO_3$), 75.80 per cent; SO_3, 0.75 per cent; calcium, present.

FOREIGN DEPOSITS.

British celestite deposits have supplied a large part of the world's demand in the past. The easily worked deposits in Triassic marls near Bristol, Wickwar, and Yate in Gloucestershire have been productive. The galena, barite, and celestite veins at Strontian, Argyllshire, and Pateley Bridge, Yorkshire, are reported to have supplied some celestite. The mineral also occurs at the Giant's Causeway, Ireland.

In Germany strontianite is found near Hamm and Münster, Westphalia; near Clausthal, in the Harz Mountains; at Bräunsdorf, Saxony; and at Leogang, Salzburg. Although the Westphalia deposits have been extensively worked, they are now largely exhausted and could not be profitably worked in competition with the celestite deposits of England.

Celestite is a common associate of sulphur in many of the Sicilian sulphur deposits. It is saved in mining, and a considerable quantity is shipped. It is said that the Sicilian celestite is not so desirable as the English for the manufacture of strontium salts.

MANUFACTURE AND USES OF STRONTIUM SALTS.

The principal commercial strontium salts are strontium hydroxide, used in some of the beet-sugar refineries of Europe, and strontium nitrate, carbonate, chloride, and chlorate, used in pyrotechnics. Small quantities of various organic and inorganic salts, such as acetate, lactate, bromide, iodide, arsenide, and phosphate are used in medicine. It is said that formerly strontium nitrate was used in the manufacture of some types of smokeless powder. The chief use of strontium salts in the United States at present is believed to be for making signal shells and lights of various kinds, in which the value of the strontium salt lies only in the brilliant red color it imparts to the flame produced by explosion or burning.

The strontium salts are made from celestite by roasting that mineral with coal to produce the soluble sulphide, leaching with water,

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and precipitating with suitable reagents. The chemical process is intricate, and the separation of relatively pure strontium salts from barium and calcium is particularly difficult.

Concerning the manufacture and purification of strontium nitrate, Roscoe and Schorlemmer[1] say:

> The purification is best accomplished by dissolving the carbonate in hydrochloric acid, precipitating the foreign metals by strontium oxide, followed by chlorine water, and then precipitating most of the barium by the addition of concentrated hydrochloric acid. Sulphuric acid is then added and the greater portion of the mixed sulphates are converted into carbonate by ammonium carbonate. The precipitate is next dissolved in dilute nitric acid and fractionally precipitated with sulphuric acid until no barium is contained in the precipitate. Calcium is removed from the nitrate by repeated precipitation of the strontium nitrate by alcohol.

Strontium monoxide can be prepared from the nitrate by ignition, and the hydroxide from the monoxide by the addition of water. The preparation of salts from the carbonate, strontianite, is more simple. The monoxide can be produced by calcination, as in preparing ordinary lime, but the temperature of the kilns must be higher. Strontium nitrate can be made from pure carbonate by dissolving the mineral in nitric acid and evaporating.

Irwin[2] describes in considerable detail the operation of strontium nitrate plants located near Los Angeles, Cal., built to take advantage of the war prices of this salt. He points out certain of the difficulties encountered not only in the roasting and leaching but also in the nitrification of the sulphide liquor.

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[1] Roscoe, H. E., and Schorlemmer, C., Treatise on chemistry, vol. 2, p. 596, 1913.
[2] Irwin, D. F., Strontium nitrate—a new industry: Eng. and Min. Jour., vol. 118, pp. 774–776, 1916.

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ABRASIVE MATERIALS.

By Frank J. Katz.

INTRODUCTION.

Industrial operations employ a great variety of abrasive materials. This chapter is concerned with only those mineral products which, as such or as essential constituents of manufactured products, are used for grinding and polishing and other abrasive operations and as cleansers or detersives. The chapter contains statistics of production, as to both quantity and value, either of the raw material alone or of material that has not been advanced beyond that stage of manufacture at which it is sold by the mine or quarry operator.

Artificial abrasives are included for comparison and because of their strong influence on the industry and markets of natural abrasives.

The statistics here given are, so far as possible, of only that part of the production of any mineral material that properly enters into the abrasive industries. Thus, only a small percentage of the sandstone quarried is used in the manufacture of abrasives, grindstones, and pulpstones, the remainder being used chiefly in the building industry. The segregation of the production is not difficult in this instance, but there is difficulty in separating the production of the diatomaceous (infusorial) earth which is used strictly for abrasive purposes from that which is used in manufacture of filters or of insulating or fireproofing material. Here the total production must be included.

On the other hand, quartz and feldspar, both of which are used as abrasives, are excluded from this discussion because the precise separation according to their uses of these materials can not be made, their principal uses being for purposes other than abrasive, and therefore they are considered in other chapters.

CONSUMPTION.

The total value of the abrasive materials which are considered in this report and which entered trade in 1916 was $5,156,098. This was an increase of $1,148,029, or 29 per cent, compared with 1915. There was increase in value of domestic production of natural and artificial abrasives amounting to 37 and 31 per cent, and imports increased about 3 per cent in value.

Among the natural abrasives a gain was shown in production of grindstones and pulpstones, oilstones and scythestones, emery, garnet, pumice, tripoli and rottenstone, and tube mill linings, and in 1916 the first marketing of domestic pebbles for grinding was recorded. The reported value of diatomaceous earth sold was less than in 1915. The total estimated value of all abrasive materials consumed in the United

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States during the years 1909–1916 is given in the following table, and the value of the different abrasive materials imported into the United States for consumption in the last four years is given in the second table.

Value of all abrasive materials[a] consumed in the United States, 1909–1916.

Year.	Natural abrasives.	Artificial abrasives.	Imports.	Total value.
1909	$1,329,750	$1,365,820	$653,779	$3,349,349
1910	1,406,805	1,604,030	977,718	3,988,553
1911	1,526,763	1,493,040	815,854	3,835,657
1912	1,601,993	1,747,120	898,892	4,248,005
1913	1,648,578	2,017,458	916,913	4,582,949
1914	1,310,042	1,685,410	728,710	3,724,162
1915	[b] 1,218,508	2,248,778	540,783	[b] 4,008,069
1916	1,664,339	2,935,909	555,850	5,156,098

[a] Exclusive of feldspar and the various forms of quartz. See chapters on feldspar and silica (quartz).
[b] Figures for 1915 revised in 1916.

Value of abrasive materials imported for consumption in the United States, 1913–1916.

Material.	1913	1914	1915	1916
Millstones and burrstones	$40,198	$15,000	$17,027	$19,816
Grindstones and pulpstones	239,386	109,539	68,892	63,277
Hones, oilstones, and whetstones	40,222	33,655	14,247	10,614
Emery and corundum	474,299	383,436	271,649	240,737
Diatomaceous earth, tripoli, and rottenstone	28,696	20,004	27,333	37,573
Pumice	93,408	92,668	65,691	116,543
Diamond dust and bort	100,704	74,408	75,944	67,290
	916,913	728,710	540,783	555,850

NATURAL ABRASIVES.

Under the head of natural abrasives in this report are included (1) millstones and related quarry products, such as chasers and dragstones, (2) grindstones and pulpstones, (3) oilstones and scythestones, (4) corundum and emery, (5) abrasive garnet, (6) diatomaceous (infusorial) earth and tripoli, (7) pumice, and (8) pebbles and lining for tube mills. The difficulty of separating abrasive quartz and feldspar from the quartz and feldspar produced for other purposes has led to their omission from the chapter on abrasives, and such information as appears about them in Mineral Resources will be found in chapters entitled "Feldspar" and "Silica" (quartz).

Natural abrasives were produced in 1916 in 29 States, which are listed below:

Alabama.....Millstones.
Arkansas.....Oilstones.
California.....Diatomaceous (infusorial) earth, pumice, and grinding pebbles.
Connecticut.....Diatomaceous (infusorial) earth.
Florida.....Tube-mill lining.
Illinois.....Tripoli.
Indiana.....Oilstones and rubbing stones.
Iowa.....Tube-mill lining.
Kansas.....Pumice.
Kentucky.....Hones.
Maryland.....Diatomaceous (infusorial) earth.
Massachusetts.....Diatomaceous (infusorial) earth.

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Michigan.....Grindstones and scythestones.
Missouri.....Tripoli.
Nebraska.....Pumice.
Nevada.....Diatomaceous (infusorial) earth.
New Hampshire.....Garnet, scythestones, and diatomaceous (infusorial) earth.
New York.....Millstones, emery, garnet, and diatomaceous (infusorial) earth.
North Carolina.....Millstones and garnet.
Ohio.....Grindstones, pulpstones, hones, oilstones, scythestones, and rubbing stones.
Oklahoma.....Tripoli.
Oregon.....Diatomaceous (infusorial) earth.
Pennsylvania.....Millstones, hones, and rottenstone.
Tennessee.....Tube-mill lining.
Utah.....“Mineral soap.”
Vermont.....Scythestones.
Virginia.....Millstones and diatomaceous (infusorial) earth.
Washington.....Diatomaceous (infusorial) earth.
West Virginia.....Grindstones.

Value of natural abrasives produced and marketed in the United States, 1912–1916.

Abrasive.	1912	1913	1914	1915	1916
Millstones	$71,414	$56,163	$43,316	$53,480	$44,559
Grindstones and pulpstones	916,339	855,627	689,344	648,479	766,140
Oilstones and scythestones	232,218	207,352	167,948	115,175	154,573
Emery	6,652	4,785	2,425	31,131	123,901
Garnet	163,237	183,422	145,510	139,584	208,850
Abrasive quartz and feldspar	(a)	(a)	(a)	(a)	(a)
Diatomaceous (infusorial) earth and tripoli	125,446	285,821	252,327	[b] 167,474	[c] 241,553
Pumice	86,687	55,408	59,172	63,185	82,263
Grinding pebbles	.....	.....	.....	.....	42,500
	1,601,993	1,648,578	1,310,042	1,218,508	1,664,339

[a] See chapters on feldspar and silica (quartz).
[b] Figures for 1915 revised in 1916.
[c] Exclusive of considerable production for special uses upon which the Survey is not at liberty to report.

MILLSTONES.

PRODUCTION.

The marketed production of millstones (burrstones) and related quarry products—chasers, dragstones, and pavers—in the United States amounted to $44,559, a decrease of 17 per cent, as compared with 1915. The production in this country in 1916 was less than in 1912, 1913, and 1915, but larger than in any other year of the last decade.

The setback which was suffered by the millstone market in the late eighties and nineties because of the introduction of modern grain-milling machinery and which is reflected in the second table has been offset to some extent in the last 20 years by the growing use of millstones for grinding mineral products, such as feldspar, quartz, and pigments.

American millstones have been and are still for the most part made of quartz sandstones and conglomerates. Some are made of granite. The production recorded in the Survey's reports on mineral resources is only that which has been made for other than purely local use. A small number of stones for local use have been made, particularly in the mountain sections of the Southern States, and various hard quartz or other rocks have been so employed.

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Millstones were produced in 1916 in Alabama, New York, North Carolina, Pennsylvania, and Virginia. Only those States have produced them in recent years.

The output increased about 10 per cent in Virginia, but decreased nearly 33 per cent in North Carolina, about 40 per cent in New York, and about 60 per cent in Pennsylvania.

Value of millstones produced and marketed in the United States, 1911–1916.

State.	1911	1912	1913	1914	1915	1916
New York	$13,335	$34,246	$21,967	$16,748	$16,883	$10,287
Virginia	17,635	25,866	23,530	20,100	23,170	25,752
North Carolina	9,099	9,352	8,772	5,164	13,427	8,520
Pennsylvania		1,950	1,874	1,304		
Alabama						
	40,069	71,414	56,163	43,316	53,480	44,559

Value of millstones produced and marketed in the United States, 1880–1916.

1880	$200,000	1893	16,639	1906	48,590
1881	150,000	1894	13,887	1907	31,741
1882	200,000	1895	22,542	1908	31,420
1883	150,000	1896	22,567	1909	35,393
1884	150,000	1897	25,932	1910	28,217
1885	100,000	1898	25,934	1911	40,069
1886	140,000	1899	28,115	1912	71,414
1887	100,000	1900	32,858	1913	56,163
1888	81,000	1901	57,179	1914	43,316
1889	35,155	1902	59,808	1915	53,480
1890	23,720	1903	52,552	1916	44,559
1891	16,587	1904	37,338		
1892	23,417	1905	37,974		

IMPORTS.

Imports of millstones for consumption in the United States in 1916 were larger than in 1915 and 1914, but less than in earlier years. In 1916 there was a slight falling off in imports of material in the rough and a large increase in imports of finished stones.

Value of burrstones and millstones imported for consumption in the United States, 1911–1916.

Year.	Rough.	Made into millstones.	Total.	Year.	Rough.	Made into millstones.	Total.
1911	$35,153	$875	$36,028	1914	$14,291	$709	$15,000
1912	26,236	1,326	27,562	1915	16,045	982	17,027
1913	36,276	3,922	40,198	1916	15,495	4,321	19,816

THE MILLSTONE INDUSTRY.

In this report for 1909 and for 1913 descriptive notes were given on the millstone industry in New York and Virginia. As the industry is one which undergoes little change from year to year, statements made in former reports may be consulted to supplement the data for 1916 in this report.

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New York.—For many years New York led in the production of millstones and chasers (stones which run on edge or on a horizontal shaft), but in recent years the State yielded first place to Virginia in production of millstones, although still leading in output of chasers. Twelve operators reported production of millstones in 1916.

Virginia.—Five operating firms or individuals reported production during 1916.

North Carolina.—Two operators reported production of millstones in 1916.

Pennsylvania.—In Lancaster County a quartz conglomerate which has been known to the trade as Cocalico stone is made into millstones. Two manufacturers reported production in 1916.

Alabama.—Near Dutton, Jackson County, millstones have been made from sandstones of Pennsylvanian age. A few stones were manufactured in 1916.

Vermont.—A quartz conglomerate rock similar to the New York. Esopus stone is found near Fair Haven, Rutland County. No millstones have been made of this rock in recent years.

Ohio.—At Peninsula, in Summit County, a white variety of the Berea grit was quarried for the purpose of grinding oatmeal and pearling barley, for which it was said to be especially well adapted. At present no millstones are made from the Berea grit.

In addition to these localities stones of different varieties and more or less suitable for coarse work are or have been quarried and fashioned for use in local mills in many States.

GRINDSTONES AND PULPSTONES.

PRODUCTION.

The value of the grindstones and pulpstones produced in the United States in 1916 was $766,140, an increase of $117,661, or about 18 per cent, as compared with $648,479, the value for 1915. The increase was in the value of both grindstones and pulpstones.

The States and the number of quarries in each State producing grindstones in 1916 were: Michigan, 2; Ohio, 22; and West Virginia, 2. Ohio, as usual, maintained the leading position in the industry, the value of the output of the State being nearly six times that of Michigan and West Virginia combined. Ohio also produced pulpstones from 2 quarries. Montana and Utah have ceased to be producers of grindstones.

Value of grindstones and pulpstones produced and marketed in the United States, 1912–1916.

State.	1912	1913	1914	1915	1916
Michigan	(a)	(a)	(a)	(a)	(a)
Montana	(a)				
Ohio	$787,621	$737,572	$606,001	$571,113	$637,919
Utah	(a)				
West Virginia	(a)	(a)	(a)	(a)	(a)
Other States	[b] 128,718	[c] 118,055	[c] 83,343	[c] 77,366	[c] 128,221
	916,339	855,627	689,344	648,479	766,140

[a] Included in "Other States."
[b] Includes Michigan, Montana, Utah, and West Virginia.
[c] Includes Michigan and West Virginia.

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Value of grindstones and pulpstones produced and marketed in the United States, 1907–1916.

1907	$896,022	1912	$916,339
1908	536,095	1913	855,627
1909	804,051	1914	689,344
1910	796,294	1915	648,479
1911	907,316	1916	766,140

IMPORTS AND EXPORTS.

The value of the imports of grindstones and pulpstones decreased in 1916 to $63,277, which was 8 per cent less than in 1915 and 42 per cent less than in 1914. The imports for the last six years and the exports for 1915 and 1916 are given as follows:

Value of grindstones and pulpstones imported for consumption in the United States, 1911–1916.

1911	$123,727	1913	$139,386	1915	$68,892
1912	131,080	1914	109,539	1916	63,277

The value of the grindstones exported from the United States in 1916 was $176,563, against exports valued at $128,879 in 1915.

CANADIAN PRODUCTION.[1]

The value of the grindstones, scythestones, and wood-pulp stones produced in Canada in 1916 [2] amounted to $50,982, as compared with $35,768 in 1915.

Value of grindstones, etc., produced in Canada, 1911–1916.

1911	$52,942	1913	$51,325	1915	$35,768
1912	52,090	1914	54,504	1916	50,982

OILSTONES AND SCYTHESTONES.

PRODUCTION.

The production of oilstones (including hones and whetstones) and scythestones in the United States during 1916 amounted to $154,573 in value, an increase of $39,398, or 34 per cent, as compared with the value for 1915. Oilstones, whetstones, and hones were produced in Arkansas, Indiana, Ohio, Kentucky, and Pennsylvania, especially in Arkansas, which has led in the production for many years. Ohio led in the production of scythestones, but New Hampshire, Vermont, and Michigan also contributed important quotas. A description of the scythestone industry in New Hampshire was given in this report for 1909, and a description of Arkansas oilstones, oilstone deposits, and industry was included in the report for 1911.

[1] From reports of Canada Dept. Mines.
[2] Preliminary report on the mineral production of Canada during 1916: Canada Dept. Mines, 1917.

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Value of oilstones and scythestones produced and marketed in the United States, 1907–1916.

1907	[1] $264,188	1912	[3] $232,218
1908	[1] 217,284	1913	[3] 207,352
1909	[2] 214,019	1914	[3] 167,948
1910	[1] 228,694	1915	[4] 115,175
1911	[2] 214,991	1916	[3] 154,573

IMPORTS.

Value of hones, oilstones, and whetstones imported for consumption in the United States, 1911–1916.

1911	$54,379	1913	$40,222	1915	$14,247
1912	45,398	1914	33,655	1916	10,614

CORUNDUM AND EMERY.

PRODUCTION.

From 1906 to 1914, inclusive, the United States produced no corundum. The Hampden Corundum Wheel Co., of Springfield, Mass., is reported to have revived corundum mining at Corundum Hill, N. C., and to have been engaged in production during 1915 and 1916. No data on the quantities produced in those years have been obtained.

The domestic production of emery since 1913 seems to have come entirely from the Peekskill region, in Westchester County, N. Y. The Geological Survey has received no report of production in the last four years from the mines in Chester, Hampden County, Mass., which had for many years produced a gradually diminishing quantity. Complete returns from New York for 1916 show an enormous increase in production. The number of producing firms increased from four to six. The quantity produced was five times that of 1915, and more than 30 times that of 1914, and was far larger than the combined domestic productions of corundum and emery in any year since 1880, the earliest for which there is record. The domestic production for 1916 was 15,282 short tons of crude emery, valued at $123,901. The average price received for the crude quarry product was about $8 f. o. b. Peekskill, which was less than the apparent price in 1915. The increase in production of domestic emery is due directly to the war, which has stimulated consumption by increase in steel grinding and has very largely cut off foreign supplies.

[1] Includes a quantity of "rubbing stone" quarried in Indiana.
[2] Includes a quantity of honestone quarried in Kentucky and "rubbing stone" quarried in Indiana.
[3] Includes a quantity of honestone quarried in Kentucky and Pennsylvania and "rubbing stone" quarried in Indiana.
[4] Includes a quantity of honestone quarried in Kentucky and Ohio and "rubbing stone" quarried in Indiana and Ohio.

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Tables showing corundum and emery produced and sold in the United States, 1881 to 1906, are included in this report for 1915 and preceding years.

Emery produced and sold in the United States, 1907–1916.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1907	1,069	$12,294	1911	659	$6,778	1914	[a]485	[a] $2,425
1908	669	8,745	1912	992	6,652	1915	[a] 3,063	[a] 31,131
1909	1,580	18,185	1913	[a]957	[a]4,785	1916	15,282	122,901
1910	1,028	15,077						

[a] Estimated.

IMPORTS.

The following table gives the quantity and value of the emery and corundum imported into the United States from all foreign countries during recent years. The year 1916 was marked by decrease in the total value, higher prices notwithstanding, of imports of all forms of emery and corundum, amounting to nearly 13 per cent as compared with 1915; 37 per cent as compared with 1914; and 49 per cent as compared with 1913. The imports have fluctuated irregularly in both quantity and value during the last decade. Nevertheless, the figures for 1916 establish a vertiable low-water mark, for which the war's interference with mining in Turkey and Greece and with shipping is responsible.

Emery and corundum imported for consumption in the United States, 1910–1916.

Year.	Grains.		Ore and rock.		Other manufactures.	Total value.
	Quantity.	Value.	Quantity.	Value.	Value.	
	Pounds.		*Long tons.*			
1910	2,311,464	$106,570	28,948	$509,661	$13,527	$629,758
1911	1,382,813	76,027	10,822	245,459	15,158	336,644
1912	2,135,922	105,325	16,391	369,529	16,871	491,725
1913	2,496,372	114,786	17,123	342,809	16,704	474,299
1914	1,781,821	79,989	12,909	280,866	22,581	383,436
1915	1,277,673	56,254	8,462	197,303	18,092	271,649
1916	1,689,689	90,646	7,623	113,176	36,915	240,737

CANADIAN CORUNDUM.

Canadian corundum shipped, 1911–1916.[a]

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1911	1,472	$161,873	1914	548	$73,176
1912	1,960	239,091	1915	339	37,798
1913	1,177	137,036	1916	[b] 67	[b] 10,307

[a] Figures taken from the annual reports on mineral production of Canada, Canada Dept. Mines.
[b] Preliminary report on mineral production of Canada during 1916, Canada Dept. Mines, 1917.

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ABRASIVE GARNET.

PRODUCTION.

The sales of domestic garnet for use as abrasive material in the United States in 1916 amounted to 6,171 short tons, valued at $208,850. This is the largest annual production except that of 1907 and is an increase of 43 per cent in quantity over 1915, 46 per cent as compared with 1914, and 16 per cent as compared with 1913. Prices, as heretofore, ranged from $30 to $40, and were prevailingly about $35 a short ton.

Abrasive garnet produced and sold in the United States, 1907–1916.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1907	7,068	$211,686	1911	4,076	$121,748	1914	4,231	$145,510
1908	1,996	64,620	1912	4,947	163,237	1915	4,301	139,584
1909	2,972	102,315	1913	5,808	188,422	1916	6,171	208,850
1910	3,314	113,574						

TRIPOLI, DIATOMACEOUS (INFUSORIAL) EARTH, AND ROTTENSTONE.

TRIPOLI.

The material called tripoli in the trade in the United States is a white or yellowish, light, porous, and generally pure siliceous rock which has resulted from the leaching of calcareous material from very siliceous limestones or highly calcareous cherts. In origin, properties, and some of its uses tripoli is like "rottenstone," which is here classed with it.

Some tripoli from Missouri is and always has been produced primarily for use as an abrasive, but most of it is mined to be worked up into filter blocks of various shapes. The cuttings and waste from making filters are ground and prepared for abrasive and other uses. The Illinois product is generally called "silica" and is used in paint, wood filler, metal polish, in soaps, in cleansers, for making glass, tile, and enamel, and for facing foundry molds.

A definite statement of the exact proportion used as an abrasive has not been obtained from producers of tripoli, nor has any attempt been made to get at the production of rough tripoli blocks worked up into filter stones. Even if this output had been ascertained it would be impossible to value the product on a uniform basis and thus to obtain a reliable ratio between quantity and value, for the reason that the price of filter stones varies and is dependent not only on the size of the stones but also on the work done on each stone.

DIATOMACEOUS EARTH.

Diatomaceous earth, called also infusorial earth and kieselguhr, is a light earthy material which from some sources is loose and powdery and from others is more or less firmly coherent. It often resembles chalk or clay in its physical properties but can be distinguished at

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once from chalk by the fact that it does not effervesce when treated with acids. It is generally white or gray in color but may be brown or even black when mixed with much organic matter.

Diatomaceous earth is made up of remains of minute aquatic plants and is composed, chemically, of hydrous silica.

Owing to its porosity it has great absorptive powers and high insulating efficiency and is an effective filter. The hardness, the minute size, and the shape of its grains make it an excellent metal-polishing agent.

Heretofore diatomaceous or infusorial earth has been largely used as an abrasive in the form of polishing powders and scouring soaps, but of late its uses have been considerably extended. Because of its porous nature it has been used in the manufacture of dynamite as a holder of nitroglycerin, but not recently in the United States. It is used by sugar refiners for filtering or clarifying. Its porosity also renders it a nonconductor of heat, and this quality in connection with its lightness has very greatly extended its use as an insulating packing material for safes, steam pipes, boilers, and metallurgic apparatus, in making insulating brick, and as a fireproof building material. In this country it is used in the manufacture of records for talking machines. In Europe, especially in Germany, infusorial earth has lately found extended application. It has been used in preparing artificial fertilizers, especially in the absorption of liquid manures; in the manufacture of water glass, of various cements, of glazing for tiles, of artificial stone; as a carrier of ultramarine and various pigments, aniline and alizarin colors; in filling paper; and in the preparation of sealing wax, fireworks, gutta-percha objects, Swedish matches, solidified bromine, scouring powders, papier-mâché, and many other articles.

ROTTENSTONE.

Rottenstone is a porous, generally loosely coherent product of the weathering and leaching of siliceous limestones. It is produced at only one locality in the United States, at Antes Fort, Lycoming County, Pa., by the Penn Keystone Co., of Williamsport, Pa. It is used chiefly as polishing and scouring material.

PRODUCTION.

Tripoli and diatomaceous (infusorial) earth have been combined for consideration in these reports for many years for the reasons (1) that, because of the confusion in names it was not expedient to make the separation in the earlier canvasses after the beginning of the production of what is now called tripoli, and (2) that uses of the materials as abrasives are in part the same. Since 1913 the production of diatomaceous earth has also been separately reported. Since 1913 the statistics of production of Pennsylvania rottenstone have been included with tripoli.

In the following tables the value of the Illinois tripoli output for 1915, which was incorrectly reported to the United States Geological Survey, has been revised.

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Diatomaceous earth and tripoli produced and sold in the United States, 1907–1916.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons.)	Value.	Year.	Quantity (short tons.)	Value.
1907	14,824	$104,406	1911	16,082	$147,462	1915[a]	35,304	[b] $167,474
1908		97,442	1912	16,706	125,446	1916[a]	45,978	241,553
1909	18,680	122,348	1913	27,383	285,821			
1910		130,006	1914	28,230	252,327			

[a] Exclusive of considerable production for special uses upon which the Survey is not at liberty to report.
[b] Value for 1915 revised in 1916.

Tripoli produced and sold in the United States, 1914–1916.

State.	1914		1915		1916	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Illinois	10,387	$59,394	23,756	[a] $59,890	33,187	$82,968
Missouri	6,721	81,434	6,955	69,567	10,070	132,248
Other States [b]	110	1,600				
	17,218	142,428	30,711	128,957	43,257	215,216

[a] Value for 1915 revised in 1916.
[b] 1914, Oklahoma and Pennsylvania; 1915, Pennsylvania and Georgia; 1916, Pennsylvania and Oklahoma.

Diatomaceous earth produced and sold in the United States, 1914–1916.

State.	1914		1915[a]		1916[a]	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Western States [b]	10,343	$98,819	3,850	$25,865	1,840	$14,700
Eastern States [c]	669	11,080	743	12,652	881	11,637
	11,012	109,899	4,593	38,517	2,721	26,337

[a] Exclusive of considerable production for special uses upon which the Survey is not at liberty to report.
[b] California, Nevada, and Washington, and Oregon in 1915; California, Nevada, and Washington in 1916.
[c] 1914: Massachusetts, Connecticut, New York, and Maryland; 1915: New Hampshire, Massachusetts Connecticut, New York, Maryland, and Virginia; 1916: Connecticut, Maryland, Massachusetts, New Hampshire, and New York.

Production of tripoli and rottenstone.—The marketed production of tripoli and rottenstone for all purposes in the United States in 1916 was 43,257 tons, valued at $215,216, an increase of 41 per cent in quantity and of 67 per cent in value as compared with 1915. The marketed production in 1915, 30,711 short tons valued at $128,957, was an increase over 1914 of 78 per cent in quantity, but, according to the revised figures in the accompanying table, a decrease of nearly 10 per cent in value. The value of the output in Illinois recorded in the report for 1915 represented an abnormally high price for ground and prepared product. The revised value here given is for crude quarry product, which for Illinois tripoli was about $2.50 a ton. The output in 1915 of Missouri tripoli, which is largely of filter grade

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and has a higher value than the Illinois product, was also in excess of that for 1914 but had a somewhat lower value.

In Illinois four mines in Union County and two in Alexander County reported production in 1916. No new deposits were developed but there were several changes in ownership or management and greatly increased activity and production. A number of mines formerly worked were idle. Crude material, as in 1915, had an average value of about $2.50 a ton. Most of the output was, however, sold in ground form at $17 to $25 a ton.

In Missouri four operators in Newton were active in 1915. There were no new deposits opened. The Racine Tripoli Co. has been succeeded by the Seneca Tripoli Co., and the Keen Kleaner Co.'s plant is now operated by the Weedron Silica Co.

Oklahoma deposits of tripoli were not productive except those of the American Tripoli Co., which are worked as part of its Newton County, Mo., plant, and therefore separate data for the two States are not obtainable.

The new operation in Tennessee described in the report for 1913 has not been productive since that year.

In Arkansas the deposits of tripoli near Butterfield have not yet become commercially productive.

In Georgia the company operating a deposit of tripoli in Murray County sold none in 1915.

Pennsylvania produced rottenstone in Lycoming County in 1916.

Production of diatomaceous earth.—The marketed production in the United States of diatomaceous earth (also called diatomite, infusorial earth, kieselguhr, tripoli, and tripolite, and sold under various trade names) amounted in part in 1916 to 2,721 short tons, valued at $26,337, besides which there was a considerable production for special uses upon which the Geological Survey is not at liberty to report. Estimates of such production were included in the statement for 1914, which is, therefore, not comparable with those for the last two years.

In 1916 the producing States were California, Connecticut, Maryland, Massachusetts, Nevada, New Hampshire, New York, and Washington.

The table shows production for 1914, 1915, and 1916 by Western and Eastern States. It will be noted that the production in the Eastern States is small in quantity but valued per ton at two to three times as much as the western output. The difference is due to the fact that the eastern product was sold as high-grade cleansing and polishing preparations, whereas the western product was sold as raw quarry product or went into the manufacture of structural materials and insulation. The difference will probably disappear when the projected industries based on the Maryland-Virginia deposits get under way. Progress in these developments was reported in 1916.

IMPORTS.

Value of tripoli, diatomaceous earth, and rottenstone imported for consumption in the United States, 1911–1916.

1911	$35,665	1913	$28,696	1915	$27,333
1912	24,253	1914	20,004	1916	37,573

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PUMICE.

PRODUCTION.

The domestic product is almost wholly a finely comminuted material not properly called pumice, which is volcanic dust or "ash" composed of minute fragments of pumiceous, glassy lava. The imported material, which comes from the Lipari Islands, a volcanic group north of Sicily in the Mediterranean Sea, is a massive, very finely pumiceous or vesicular rock. Very little pumice of this type has been produced in the United States.

The statistics given represent pumice used for abrasive purposes solely. The pumice used for construction—and it is known that some of the domestic article has been so used—is not included. The material has come from several counties in six States—Inyo, Imperial, and Siskiyou counties in California; Harper, Morton, and Phillips counties in Kansas; Furnas, Lincoln, and Harlan counties in Nebraska; Custer County in South Dakota; Cassia and Power counties in Idaho; and Millard County in Utah. Available deposits are very widespread and are particularly abundant in all the Great Plains States from South Dakota to Texas.

The Nebraska Geological Survey has recently published an excellent description of the Nebraska occurrences with a discussion of the origin, distribution, and mining of pumice dust deposits, and of the characteristics and uses of the material.[1]

The marketed production of pumice in the United States in 1916 amounted to 33,320 short tons, valued at $82,263, an increase of 5,612 tons, or about 20 per cent, in quantity and of $19,078, or about 30 per cent, in value, as compared with 1915. In 1916 California produced a small amount; the Kansas production increased very largely and exceeded that from Nebraska, which for a number of years had been the leading State.

Pumice produced and sold in the United States, 1910–1916.

Year.	Quantity (short tons).	Value.	Price per ton.	Year.	Quantity (short tons).	Value.	Price per ton.
1910	23,271	$94,943	$4.08	1914	27,591	$59,172	$2.14
1911	21,689	88,399	4.08	1915	27,708	63,185	2.28
1912	27,146	86,667	3.19	1916	33,320	82,263	2.47
1913	24,563	55,408	2.26				

IMPORTS.

Value of pumice imported for consumption in the United States, 1911–1916.

1911	$118,977	1913	$93,408	1915	$65,691
1912	74,478	1914	92,668	1916	116,543

PEBBLES FOR GRINDING.

Pebbles used for grinding minerals, ores, cement materials, and clinker may be properly considered abrasive materials. This report prior to 1914 had not included them because none had been produced

[1] Barbour, E. H., Nebraska pumicite: Nebraska Geol. Survey Rept., vol. 4, pt. 27, 1916.

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in the country, except for limited local use of which no record was obtained, and also because the records of imports of foreign pebbles for grinding are not kept separate from those of pebbles which are crushed and used as "flint" in the ceramic industry. Chapters on quartz or flint in Mineral Resources have annually given the quantity of the imports of pebbles used both for grinding and as flint. Little or no interest had been taken in domestic sources of flint pebbles until the fall of 1914, when the threatened interruption of imports from Denmark and France, the principal sources of foreign supply, aroused American jobbers and consumers to seek independence from the established foreign sources.

Domestic pebbles for grinding.—Information on domestic sources of flint or other grinding pebbles and substitutes therefor is summarized in the report on abrasive materials in Mineral Resources for 1914. Since that time further information has been obtained on deposits of novaculite pebbles in Arkansas.

In Pike, Howard, and Sevier counties of that State there are extensive gravel beds containing abundant well-rounded pebbles of novaculite of sizes suitable for tube mill grinding. Novaculite is a very hard and dense rock composed essentially of silica. A report on these pebble deposits is being prepared by H. D. Miser and A. H. Purdue for publication by the United States Geological Survey.

In 1916 pebbles for grinding ores and cement clinker were obtained from the beaches between Oceanside and Encinitas, San Diego County, Cal. These were gathered by several individuals and firms whose names and addresses may be obtained from the United States Geological Survey. The smooth round or nearly round pebbles are picked out by hand on the beaches and assorted according to size, ranging from 2 to 7 inches in diameter. Samples submitted to the Geological Survey contained chiefly pebbles of fine-grained tuffs, porphyries, and granites. They are all tough rocks and are said to be harder to break than Danish flint pebbles, but being coarser grained than flints they wear somewhat faster on hard ores and are less smooth. Cement grinders are said to have found these pebbles as efficient as the imported flints, the waste per ton of finished cement being about 1¼ pounds of California pebbles. With extremely hard ores the California pebbles are reported to be only about 50 per cent efficient in comparison with Danish flints. One metallurgic company reported that the wastage of pebbles per ton of ore ground is 16 pounds as compared with 9 pounds of Danish flints, with additional advantage for the latter in the smaller load required to accomplish the grinding, which reduces the efficiency of the California pebbles to about one-half that of the Danish flint. However, it is economical to use the domestic pebbles because they cost less than half the price of Danish flints.

In 1916 about 6,000 tons of pebbles were sold in San Diego County at an average price of $6 a ton f. o. b. cars at loading points.

Mr. Omer Maris, of Manhattan, Nev., continued the manufacture of artificially rounded pebbles in 1916 and supplied metallurgic mills in the vicinity of his plant.

A number of gold mills are using wholly or in part lumps of ore or native rocks in place of pebbles.

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IMPORTS.

In the accompanying tables are given the value both of imports "for consumption" and of "general" imports classified according to countries of origin.[1] Both groups of figures are of interest to the present discussion.

Value of pebbles and flint imported for consumption in the United States, 1909–1916.

1909	$301,547	1913	$324,662
1910	307,286	1914	432,694
1911	236,158	1915	274,904
1912	289,904	1916	313,120

Value of general imports of pebbles and flint into the United States, 1912–1916.

Country.	1912	1913	1914	1915	1916
Belgium	$99,472	$40,947	$70,851	.....	.....
British India	.....	.....	.....	.....	$2,440
Canada	14,141	8,599	63,998	$1,128	.....
Denmark	78,123	134,625	193,029	152,129	175,916
England	870	2,626	2,199	1,303	.....
France	99,140	121,854	116,571	91,024	117,649
Germany	67	2	91	.....	.....
Italy	.....	.....	22	.....	.....
Japan	.....	.....	12	97	7,924
Newfoundland and Labrador	.....	10,800	8,448	.....	.....
Norway	239	.....	1,846	.....	1,780
Portugal	.....	.....	.....	.....	214
Sweden	.....	56	22,081	28,098	7,197
	292,052	319,509	479,146	273,769	313,120

The exact quantity of pebbles annually imported for grinding is not determinable, as the records show only the total combined value of all kinds of pebbles imported. Apparently the larger part of the imports from Belgium, Denmark, and France are for grinding pebbles and they are flint pebbles. The whole imports from Canada, Newfoundland, and Labrador are probably grinding pebbles that are not flint. Much of the value credited to England and some of that credited to Belgium, Denmark, and France is for flint which, after arrival in this country, is pulverized for use by potters.

The data in these tables show much larger value for imports in 1914 and considerably smaller in 1915 than in 1913 with apparent return to normal imports in 1916. However, as the quantities imported are not recorded, it is not certain that the high prices current late in 1914 and in 1915 were due to actual or merely threatened shortage in imports. Recent normal and even low prices indicate that there have been ample shipments of foreign flint pebbles.

TUBE-MILL LINING.

So-called "flint liners" for tube mills, which are dimension blocks cut from flint or other hard siliceous rock, had been obtained almost wholly from Belgium. The war cut off that supply and caused high prices and considerable inconvenience in securing tube mill liners in

[1] These figures are not identical because merchandise brought into the country and listed under "general imports" may be put into a warehouse and not be withdrawn for consumption during the calendar year of entry. It is credited "for consumption" to the year of its withdrawal from the warehouse.

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this country. American substitutes are now obtainable from S. W. Chiles, Bethlehem, Pa., who has obtained a supply of flint from the Ocala limestone in Florida; from E. R. Lull, Iron City, Tenn., who makes dimension blocks from the Fort Payne chert; and from the Jasper Quarry Co., Sioux City, Iowa, which manufactures standard block and blocks cut to specifications from the Sioux quartzite. These manufacturers have marketed tube mill lining in 1916. Data on the quantity and value of their production are not available for publication.

MINERAL SOAPS AND DETERSIVES.

Small quantities of so-called mineral soaps and natural mineral products which have cleansing or detersive qualities are marketed annually.

The Silver-ile Products Co., of Salt Lake City, manufactures an article which has effective soaplike qualities, partly derived from a clayey, probably colloidal earth, and partly from diatomaceous earth.

A pumice dust or fine volcanic ash from Oregon has been marketed as a medicinal detersive.

ARTIFICIAL ABRASIVES.

The artificial abrasives here considered are of three kinds: (1) Crushed crucible steel, crushed chilled iron, and crushed cast iron, manufactured by the Pittsburgh Crushed Steel Co., Pittsburgh, Pa. (2) The silicon carbides carborundum, manufactured by the Carborundum Co., at Niagara Falls, N. Y.; crystolon, manufactured by the Norton Co., of New York, at Niagara Falls, N. Y.; and carbolon, manufactured by the Exolon Co., at Blaisdell, N. Y., and Thorold, Ontario. (3) The aluminum oxides aloxite, manufactured by the Carborundum Co., at Niagara Falls, N. Y.; alundum, manufactured by the Norton Co., of New York, at Niagara Falls, N. Y.; exolon, manufactured by the Exolon Co., at Blaisdell, N. Y., and Thorold, Ontario; and lionite, manufactured by the General Abrasives Co., at Niagara Falls, N. Y.

So far as known to the Survey, these are the only artificial abrasives manufactured in the United States. Artificial abrasives with other names are either special forms of the above-named products marketed under trade names or are imported products.

Artificial abrasives sold in the United States, 1906–1916.

Year.	Quantity (pounds).	Value.	Year.	Quantity (pounds).	Value.
1906	11,774,300	$777,081	1912	29,002,000	$1,747,120
1907	14,632,000	1,027,246	1913	33,489,000	2,017,458
1908	8,698,000	626,240	1914	27,191,611	1,685,410
1909	20,468,000	1,365,820	1915	37,684,000	2,248,778
1910	23,027,000	1,604,030	1916	77,682,000	2,935,909
1911	21,292,000	1,493,040			

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SALT, BROMINE, AND CALCIUM CHLORIDE.[1]

By R. W. STONE.

SALT.

PRODUCTION.

Of all the common mineral commodities used by the human race salt is the one for which in its most common use, in food for men and animals, there is no substitute. Its consumption by any nation increases with the population. The more civilized the nation the greater is the consumption of salt per capita, for besides its use in food it plays a part in many chemical and metallurgical industries.

The United States has inexhaustible supplies of salt and can supply not only her own needs but those of the world for a long time to come. The salt is well distributed, the production coming from New York on the east, California on the west, Michigan on the north, Louisiana on the south, and also from several Central States. The extent of the deposits is suggested by the fact that in New York, for example, an area of 2,000 square miles in the central counties is underlain by a rock-salt deposit whose thickness ranges from 8 feet to 318 feet. This deposit alone would supply the whole United States for thousands of years. In Louisiana and Texas deep drill holes have revealed the presence of tremendously thick deposits of rock salt at a depth of a few hundred feet. Thicknesses of 2,000 feet are common, and one drill hole passed through more than 3,000 feet of rock salt.

The production has tended to increase steadily for many years and in 1916 was 6,362,906 short tons. This was a 1,000,000-ton increase over the production of 1915. As the mines and manufacturing plants for many years have not been producing anything like their capacity it shows what can be done if a demand should arise for enlarged output. The following table shows the quantity of domestic salt sold in the United States in the last five years:

Salt produced and marketed in the United States, 1912–1916.

Year.	Quantity.				Total value.	Average price per ton.
	Manufactured (evaporated) (short tons).	In brine (short tons).	Rock salt (short tons).	Total (short tons).		
1912	2,075,420	1,597,207	992,846	4,665,473	$9,402,772	$2.02
1913	2,131,229	1,622,382	1,062,291	4,815,902	10,123,139	2.10
1914	2,159,094	1,652,758	1,060,304	4,872,656	10,197,417	2.09
1915	2,335,823	1,851,199	1,165,387	5,352,409	11,747,686	2.19
1916	2,454,836	2,539,717	1,368,353	6,362,906	13,645,947	2.14

[1] The statistical part of this report is the work of Miss A. T. Coons for domestic material and of J. A. Dorsey for imports and exports.

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All tables relating to salt are for the first time given in short tons instead of in tons, barrels, and pounds as heretofore, in order to afford more ready comparison. The change is appropriate, as 70 per cent of the operators report their production in tons. It is hoped that the change will meet the approval of the salt trade.

GENERAL STATISTICS.

The following table presents in concise form general statistical information of interest to the salt trade:

Operating salt plants, rank of States, and average price per ton in 1915 and 1916, and percentage of increase or decrease in 1916.

State.	1915				1916				Percentage of increase or decrease in 1916.	
	Number of operating plants.	Rank of State by—		Average price per ton.	Number of operating plants.	Rank of State by—		Average price per ton.	Quantity.	Value.
		Total quantity.	Total value.			Total quantity.	Total value.			
California	[a] 25	7	5	[b] $3.98 [c] 4.73	[a] 26	7	5	[b] $2.99 [c] 4.20	+ 7.2	− 5.3
Hawaii	[c] 1	12	11	[c] 8.00	[c] 1	12	12	[c] 7.00	− 58.3	− 53.1
Idaho	[c] 1	16	16	[c] 10.00	[a] 3	15	16	[b] 10.00 [c] 15.00	+340.0	+411.0
Kansas	[a] 10	4	4	[b] 1.34 [c] 2.55	[a] 10	4	4	[b] 1.35 [c] 2.61	+ 21.2	+ 25.7
Louisiana	[b] 2	5	6	[b] 2.52	[b] 2	5	7	[b] 2.28	+ 1.2	− 8.5
Michigan	[a] 27	1	1	[b] 2.02 [c] 2.43	[a] 27	1	1	[b] 2.60 [c] 2.18	+ 18.5	+ 7.2
Nevada	[c] 3	14	14	4.07	[c] 2	13	14	[c] 4.35	− 36.1	− 31.6
New Mexico	[c] 1	13	13	[c] 2.76	[c] 1	12	13	[c] 2.00	− 50.0	− 44.5
New York	[a] 26	2	2	[b] 1.95 [c] 1.86	[a] 25	2	2	[b] 1.98 [c] 1.81	+ 25.6	+ 24.3
Ohio	[c] 10	3	3	[c] 1.78	[c] 10	3	3	[c] 2.17	+ 12.8	+ 39.4
Oklahoma	[c] 2	15	15	[c] 6.91	[c] 2	14	15	[c] 6.23	+ 70.9	+ 50.4
Porto Rico	[c] 2	11	10	[c] 2.57	[c] 2	11	10	[c] 2.62	+ 18.6	+ 20.6
Texas	[c] 5	8	7	[c] 5.55	[c] 5	8	6	[c] 5.46	+ 21.6	+ 23.5
Utah	[a] 7	9	8	[b] 2.29 [c] 5.04	[a] 7	9	8	[b] 2.24 [c] 4.99	+ 9.7	+ 8.7
Virginia	[c] 1	6	12	.....	[c] 1	6	11	.....	+ 14.0	.....
West Virginia	[c] 4	10	9	[c] 3.54	[c] 4	10	9	[c] 3.67	+ 2.7	+ 6.5
Total brine and rock salt	127	.....	.....	[b] 1.97 [c] 2.26	128	.....	.....	[b] 1.95 [c] 2.62	.....	.....
Total United States	.....	.....	.....	2.19	.....	.....	.....	2.14	+ 18.9	+ 16.2

[a] Includes both rock and brine salt. [b] Rock salt. [c] Brine salt.

It will be noted that Michigan, New York, and Ohio rank first, second, and third, respectively, in both quantity and value of product, as in former years. In 1916 the quantity produced in Hawaii and New Mexico was the same; hence each has the same rank.

The exceptionally high price of Idaho salt is explained by the fact that a very small production in an isolated district has a purely local market among neighboring ranches. The high percentage of decrease in production in some States in spite of a general increase in the country as a whole was caused by one of two or three producers ceasing operations; in New Mexico it was caused by a flood on the property of the only producer.

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PRODUCTION BY GRADES.

GENERAL FEATURES.

Two kinds of salt are produced in this country—rock salt and brine salt. Rock salt occurs in beds that range from a few feet to hundreds of feet in thickness, and are associated with bedded or sedimentary deposits. In most places it is mined through shafts like coal, and the lumps of salt are broken and sized just as coal is prepared for the market.

Brine salt is made from natural and artificial brines. The larger part of our domestic salt is derived by running fresh water down drill holes into the beds of rock salt and pumping the artificial brine to the surface, where it is evaporated. In a few places natural brine is pumped to the surface and evaporated and in others it is derived from the ocean or from salt lakes.

The simplest method of producing different grades of salt is the mining and crushing of rock salt, which is screened to different sizes for use in refrigerating, tanning, pickling, and in chemical industries. The most complex method is the evaporation of brine to make coarse salt which is cleaned, dissolved in pure water, sterilized, filtered, and evaporated again, dried, screened to various grades, and packed for the table, the kitchen, the creamery, and all the diversified uses of salt. Solar evaporation and vacuum-pan evaporation are the methods used for making most of the brine salt.

In addition to the marketable salt produced by evaporating brine, there is a considerable quantity of sodium chloride that does not enter the market as such, but is converted into sodium carbonate or bicarbonate or other sodium salts and is sold in these forms.

ROCK SALT.

Rock salt produced and marketed in the United States,[a] 1912–1916.

Year.	Quantity (short tons.)	Value.
1912	992,846	$1,697,829
1913	1,062,291	1,968,567
1914	1,060,804	2,024,898
1915	1,165,387	2,299,894
1916	1,368,353	2,665,270

[a] California, Kansas, Louisiana, Michigan, New York, and Utah; in 1916 Idaho also.

This table shows an increase in 1916 of 17.4 per cent in quantity and 15.9 per cent in value over the production of 1915.

BRINE SALT.

The various grades of salt produced by evaporating natural and artificial brine are put on the market under different trade names. The quantity and value of several grades of this salt are shown in the following table:

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Brine salt produced and marketed in the United States, 1912–1916.

Year.	Table and dairy.		Packers' salt.					
			Common fine.		Common coarse.		Packers'.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1912..	554,603	$3,164,638	842,947	$2,109,076	385,473	$1,096,643	105,217	$296,238
1913..	543,394	3,223,836	912,948	2,423,012	485,097	1,414,760	(a)	(a)
1914..	577,020	3,221,007	873,301	2,393,588	530,483	1,453,484	.....	.....
1915..	607,749	3,720,020	981,829	2,762,450	536,774	1,724,503	.....	.....
1916..	654,601	4,326,531	1,048,032	3,314,795	567,985	1,958,094	.....	.....

Year.	Coarse solar.		Other grades.		In brine.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1912..	154,831	$408,939	32,349	$59,093	1,597,207	$570,316	3,672,627	$7,704,943
1913..	162,631	446,342	27,159	67,608	1,622,382	579,014	3,753,611	8,154,572
1914..	151,228	451,206	27,062	73,715	1,552,758	589,519	3,811,852	8,172,519
1915..	162,569	508,402	46,902	130,452	1,851,199	601,965	4,187,022	9,447,792
1916..	116,913	339,079	67,305	210,337	2,539,717	831,841	4,994,553	10,980,677

a A small output reported directly as packers' salt is included under common coarse salt.

The decrease in quantity of coarse solar salt produced in 1916 is accounted for in part by heavy rains and floods that destroyed part of the product in California and by shortage of labor in New York.

The most striking feature in the table is the increase in quantity of brine salt sold as such or used by chemical works. In 1915 the quantity was 1,851,199 short tons, equivalent to 13,222,848 barrels, and in 1916 it was 2,539,717 short tons, equivalent to 18,140,836 barrels. The value increased from $601,965 in 1915 to $831,841 in 1916, an increase of 37.2 per cent in quantity and 38.2 per cent in value.

Products made by chemical companies from this 2,500,000 tons of brine salt include salt cake, soda ash, caustic soda, sodium bicarbonate, sodium carbonate, sodium acetate, sodium chlorate, sodium phosphate, sal soda, Glauber's salt, calcium chloride, chlorine, and hydrochloric acid.

The brine sold as such or used by chemical companies being omitted, the evaporated salt was produced in the States and quantities shown in the following table:

Evaporated salt produced and marketed in the United States in 1916.

State.	Quantity (short tons).	Value.
California	154,375	$647,951
Kansas	267,698	906,213
Michigan	934,862	3,783,338
New York	502,314	2,053,009
Texas	75,762	427,119
Utah	55,901	278,828
West Virginia	33,389	122,669
Hawaii, Idaho, Nevada, New Mexico, Ohio, Oklahoma, and Porto Rico	430,535	1,929,209
Total, 1916	2,454,836	10,148,836
Total, 1915	2,335,823	8,845,827
Percentage of increase in 1916	5.1	14.7

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PRODUCTION BY STATES.

Salt produced and marketed in the United States, 1913–1916.

State.	1913		1914		1915		1916	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Michigan	1,614,032	$3,293,032	1,633,937	$3,299,005	1,762,430	$4,304,731	2,088,559	$4,612,567
New York	1,509,272	2,865,187	1,454,504	2,824,733	1,570,446	2,976,405	1,972,285	3,698,798
Ohio	743,419	1,318,156	767,597	1,320,554	823,234	1,462,192	938,867	2,038,749
Kansas	377,731	860,404	415,501	924,550	527,123	1,035,879	639,071	1,302,359
California	151,619	759,485	154,062	782,920	146,784	694,070	157,393	656,975
West Virginia	15,949	63,803	20,360	78,036	32,513	115,143	33,389	122,669
Texas	49,774	278,008	46,897	251,493	62,297	345,944	75,762	427,119
Utah	46,262	191,686	52,564	231,512	55,279	266,334	60,653	289,457
Hawaii	850	5,950	.....	.....	(a)	(a)	(a)	(a)
Idaho	(a)	(a)	42	520	(a)	(a)	44	511
Nevada	1,256	7,947	621	2,448	970	3,950	(a)	(a)
Other States	[b] 305,738	479,481	[c] 326,571	481,646	[d] 371,333	543,038	[e] 396,883	496,743
	4,815,902	10,123,139	4,872,656	10,197,417	5,352,409	11,747,686	6,362,906	13,645,947

[a] Included in "Other States."
[b] Includes Idaho, Louisiana, New Mexico, Oklahoma, Pennsylvania, Porto Rico, and Virginia.
[c] Includes Louisiana, New Mexico, Oklahoma, Pennsylvania, Porto Rico, and Virginia.
[d] Includes Hawaii, Idaho, Louisiana, New Mexico, Oklahoma, Porto Rico, and Virginia.
[e] Includes Hawaii, Louisiana, Nevada, New Mexico, Oklahoma, Porto Rico, and Virginia.

PRODUCING LOCALITIES.

Salt was produced in 1916 in the States and counties listed below:

ROCK SALT.

California: San Bernardino.
Idaho: Bannock and Bear Lake.
Kansas: Ellsworth and Rice.
Louisiana: Iberia Parish.
Michigan: Wayne.
New York: Livingston.
Utah: Sevier.

BRINE FROM WELLS.

California: Solano.
Idaho: Bannock.
Kansas: Harper and Reno.
Michigan: Bay, Isabella, Manistee, Saginaw, St. Clair, and Wayne.
Nevada: Churchill.
New York: Genesee, Livingston, Onondaga, Schuyler, Tompkins, and Wyoming.
Ohio: Cuyahoga, Lake, Medina, Meigs, Summit, and Wayne.
Oklahoma: Blaine.
Texas: Anderson, Crane, Mitchell, and Van Zandt.
Virginia: Smyth.
West Virginia: Kanawha and Mason.

BRINE FROM SEA AND LAKE WATER.

California: Alameda, Los Angeles, Monterey, San Diego, and San Mateo.
Utah: Salt Lake.

SOLAR SALT FROM DESERT BASINS.

California: Inyo, Kern, Modoc, and San Bernardino.
Nevada: Churchill and Washoe.
New Mexico: Torrance.
Utah: Tooele.

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DOMESTIC CONSUMPTION.

The following table shows that very nearly all the salt used in the United States in 1916 was of domestic origin. Part of our domestic production was exported, but the exports were more than offset by imports, which were 1.9 per cent of the total consumption.

Supply of salt for domestic consumption, 1890–1916, in short tons.

Source.	1890	1900	1910	1914	1915	1916
Domestic production	1,242,779	2,921,708	4,242,792	4,872,656	5,352,409	6,362,906
Imports	257,323	199,909	137,103	130,804	122,326	122,079
Total	1,500,102	3,121,617	4,379,895	5,003,460	5,474,735	6,484,985
Exports	2,464	7,511	49,013	82,295	80,474	84,065
Domestic consumption	1,497,638	3,114,106	4,330,882	4,921,165	5,394,261	6,400,920
Comparison with preceding year	+122,865	+178,449	+6,444	+20,789	+473,096	+1,006,659
Percentage of imports to total consumption	17.2	6.4	3.2	2.7	2.3	1.9

IMPORTS.

According to figures obtained from the Bureau of Foreign and Domestic Commerce, Department of Commerce, and after conversion from pounds as reported by that bureau to short tons, the salt imported and entered for consumption in the United States in the last three years is as follows:

Salt imported and entered for consumption in the United States, 1914–1916.

Year.	In bags, barrels, and other packages.		In bulk.		Total quantity (short tons).	Total value.
	Quantity (short tons).	Value.	Quantity (short tons).	Value.		
1914	32,807	$212,349	97,997	$168,454	130,804	$380,803
1915	28,724	196,593	93,602	169,859	122,326	366,452
1916	24,402	200,220	97,677	142,368	122,079	342,588

In 1916 about 35 per cent of the salt imported came from the West Indies. The bulk of it was valued at about $1.40 a ton, and the total value was 18 per cent of the total value of imported salt. Spain furnished 28 per cent in quantity and 10 per cent in value, and England 25 per cent in quantity and 64 per cent in value. The Spanish salt was valued at a little over $1 a ton and the English salt above $7 a ton. Italy and Canada supplied about 6,000 and 8,000 tons, respectively.

EXPORTS.

The exports of salt in 1916 were more than 4 per cent greater in quantity and more than 7 per cent less in value than in 1915, a reversal of the condition in 1915, when the quantity was less than in the previous year but the value was greater. The accompanying table is made from figures obtained from the Bureau of Foreign and Domestic Commerce.

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Salt of domestic production exported from the United States, 1912–1916.

Year.	Quantity.		Value.
	Pounds.	Equivalent in short tons.	
1912	124,819,713	62,410	$418,525
1913	140,578,092	70,289	515,194
1914	164,589,012	82,295	586,055
1915	160,948,077	80,474	613,847
1916	168,129,201	84,065	567,441

BROMINE.

Bromine is made in connection with the manufacture of salt at Mount Pleasant, Midland, Saginaw, St. Charles, and Bay City in Michigan; at Pomeroy in Ohio; and at Mason, Hartford, and Malden in West Virginia.

The element bromine does not occur in native form but is derived in large quantities from natural brines. It exists in all sea water and in most mineral water and salt springs. Bromine is at ordinary temperature a volatile, heavy, mobile liquid of a reddish-brown color, giving off reddish-brown vapor. The vapor when inhaled dilute resembles chlorine in smell and in attacking the throat and nose, but in addition it has a very harmful effect on the eyes. The liquid is very poisonous and produces burns on the skin.

Bromine is used in many chemical reactions as an oxidizer instead of chlorine; in dissolving gold and separating it from platinum and silver; and in manufacturing disinfectants, bromine salts, and aniline colors. Perhaps the best known and most widely used bromine salts are bromide of silver, used in photography, and potassium bromide, used in medicine for nervous diseases where it is desirable to depress the nervous system. Recently bromine has been extensively used in making the asphyxiating gases employed in the European war.

In Michigan the bromine has been marketed as fine chemicals, but the increase in demand brought on by the war has caused a great deal of the bromine to be marketed in the crude state. Along the Ohio River bromine has for many years been produced for export for manufacture into fine chemicals.

The quantity of bromine marketed in 1916 was a decrease of nearly 15 per cent from the production of the preceding year. The increased price caused a considerable increase in total value in 1916 over 1915, as is shown in the following table, in which the figures for 1916 have been revised since the publication of the preliminary statement:

Bromine produced and marketed in the United States, 1910–1916.

Year.	Quantity (pounds).	Value.	Average price per pound.
1910	245,437	$31,684	$0.13
1911	651,541	110,902	.17
1912	647,200	145,805	.23
1913	572,400	115,436	.20
1914	576,991	203,094	.35
1915	855,857	856,307	1.00
1916	728,520	951,932	1.31

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The prices in the table are derived from the total quantity and value as reported to the Geological Survey by the producers and represent average prices for the year f. o. b. at the plants. The price of bromine in New York during the first half of 1916 ranged from $4.75 to $6.50 a pound, as a result, at least in part, of the unprecedented demand from abroad. These prices include cost of transportation and dealers' profits. In March, 1917, the price of bromine in New York had fallen to $1.30 a pound.

CALCIUM CHLORIDE.

PRODUCTION.

Calcium chloride is made from natural brines at Mount Pleasant and Saginaw, Mich.; Pomeroy, Ohio; and Mason, Hartford, and Malden; W. Va. As the same brines yield salt and bromine, practically every constituent in them is turned to profit. The quantity of calcium chloride produced from natural brines and sold in the United States has recently been about 20,000 short tons a year, valued at $6 to $7 a ton. Since the first half of 1916 there has been a demand for this material which has raised the price, as shown in the following table:

Calcium chloride produced and marketed in the United States, 1910–1916.

Year.	Quantity (short tons).	Value.	Average price per ton.
1910	10,971	$74,713	$6.81
1911	14,606	91,215	6.25
1912	18,550	117,272	6.32
1913	19,611	130,030	6.63
1914	19,403	121,766	6.28
1915	20,535	130,830	6.37
1916	26,062	216,729	8.31

This table shows that there was an increase of 26.9 per cent in quantity and of 65.7 per cent in value in 1916 over the sales of 1915. The calcium chloride accounted for in these figures does not include the output obtained in the manufacture of soda, as calcium chloride so obtained is not an original constituent of brine. Large quantities made as a by-product in the manufacture of soda have been wasted, and it is hoped that new uses may be found to prevent this waste.

USES.

The following are some of the more important uses of calcium chloride, but no data are at hand to show the quantity consumed for each use.

Prevention of dust.—Because of its strong affinity for water, a sprinkling with calcium chloride will keep a road moist and therefore dustless for several weeks. In such climatic conditions as prevail in the North Atlantic States four applications during the sprinkling season will under normal conditions keep a road free from dust and obviate the necessity of daily wetting with water. One thousand gallons of 20 per cent solution made with 3 pounds of calcium chloride to the gallon of water will suffice for the first application on a 24-foot road for a length of 125 yards. For later applications 400 gallons will suffice. It may be used on tennis courts and other playgrounds for the same purpose.

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Brine for refrigerating machines.—In machinery for making ice used in ice factories, meat packing houses, cold-storage warehouses, chemical works, and oil refineries brine is pumped through coils. A calcium-chloride solution will withstand lower temperature without freezing than salt brine and has an advantage over the brine because it has no action on iron or brass, thus giving longer life to the pumps, coils, and tanks. Calcium chloride costs more than salt, but less of it is required for a given amount of refrigeration.

Protection against fire.—A solution of calcium chloride in fire buckets has an advantage over water in that it does not corrode metal, has a lower freezing point, and does not become foul. Because of its affinity for water it tends to keep the buckets full by extracting moisture from the atmosphere.

It has long been known that brine is much more effective than water in extinguishing a fire. This is due to the fact that when the brine is thrown on a fire the liquid evaporates and the salt is left as a protective coating on the burning surface. A solution of calcium chloride, therefore, whether in an automatic sprinkler system or in a fire bucket is especially valuable.

Prevention of freezing.—A 20 per cent solution of calcium chloride in water jackets of automobile gasoline engines is effective and much less expensive than alcohol and other liquids used to prevent freezing, at any temperature higher than —9° F. (—23° C.).

It is possible to use Portland cement mortar in freezing weather by mixing calcium chloride with the cement in the proportion of 3 to 100. The calcium chloride retards the setting of the mortar and by reason of its low freezing point prevents the mortar from freezing. For the same reason calcium chloride can be used advantageously to keep ice from railroad frogs and switches, and for other similar purposes in which salt is used.

Ground saturated with a heavy solution of calcium chloride will not freeze, a knowledge of which fact may at times be useful in making excavations in cold weather.

Miscellaneous uses.—For preserving timbers, especially railroad ties and fence posts, and for the manufacture of certain dry colors, as eosin lake, turkey red, maroon, and Bremen blue, calcium chloride is substituted for more expensive material. A concentrated solution is used for tempering iron and steel in preference to pure water because the brine has a higher specific gravity and higher boiling point, produces steam less readily, and cools the hot metal better. The objection to steam is that its formation on the surface of the metal retards the cooling action of the water.

Calcium chloride is said to improve wall plaster made of magnesium lime by increasing the binding or cementing power and making a a harder wall. A solution of calcium chloride of such a density that it will not boil at 240° to 250° F. is used in canning vegetables, the sealed cans being submerged in the hot solution long enough to complete the cooking. The temperature of the bath is uniform and easily regulated and the solution will not boil even if the steam pressure varies.

In the chemical laboratory and in the manufacture of certain chemicals calcium chloride, because of its affinity for water, is used to dry gases. It is an important drying agent. Its use is valuable in drying fruits and vegetables because it removes the moisture rapidly and at low temperatures.

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THORIUM MINERALS.

By WALDEMAR T. SCHALLER.

INTRODUCTION.

The domestic deposits of monazite sand, the only thorium mineral produced in this country, are described in several papers, listed on pages 236–237. This report states the conditions of the monazite sand industry throughout the world in a quantitative way rather than in a descriptive way, so that the intending producer of domestic sand can see what he would have to compete with and, from the qualities of his own sand, can judge for himself whether he can profitably undertake the production of his particular lot of sand. The monazite sand industry in the United States was prosperous at the beginning of this century and continued so until about 1910, after which the production ceased entirely for several years. Some sand has been mined and marketed since 1914, but the industry has in no way regained its prosperity of a decade or two ago.

The oxide of thorium, or thoria (ThO_2), glows intensely when heated and is therefore used in making incandescent mantles for gas lights. Thoria is obtained by ignition of the nitrate, the thorium salt that is handled on the market. After a thorium mineral is mined and shipped, two factors chiefly determine its value—the quantity and the ease of extraction of the thoria contained in the mineral. Obviously, then, a mineral corresponding in composition to thoria would be the most valuable, and the mineral thorianite, which has this composition, is in fact the most valuable of such minerals. The only known commercial deposits of thorianite, those of Ceylon, have been worked out, and although several other minerals high in thoria (thorite, auerlite, and others) have been mined to a small extent, only a single mineral, monazite, has been found in quantities sufficient to yield a continuous production for many years.

CONDITION OF INDUSTRY.

The United States, Brazil, and India have produced practically all the monazite consumed. Several other countries have yielded small quantities, but relatively their production has been insignificant. Some of these deposits, at present idle, may prove to be of value if the price of thorium nitrate continues to advance.

Monazite was found in the Carolinas in 1879, and the placer deposits there were first worked about 1886. The next year the mineral was shipped and more or less has been mined and shipped ever since. The quantity produced in the United States reached its maximum in 1895. In this year monazite sand from the rich coastal deposits of Brazil entered the market, and in the next few years the domestic production fell to almost nothing, the combined total for 1896 and 1897 being valued at about $3,500. Increased

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demand soon caused a revival in the domestic output, which in 1905 again approached the maximum. From 1893 to 1910, inclusive, there was a large production of monazite in this country; from 1911 to the present time the production has been slight, notwithstanding the increased consumption of thorium nitrate.

To what is this decline in the domestic production due? A comparison of the figures of production and imports in the table on page 225 shows that the decline in the price of manufactured thorium nitrate has been accompanied by a marked decline in the domestic production of the crude mineral; that this decline in domestic production has been accompanied by an increase in the imports of crude mineral from foreign countries, and that this increase of imports of crude mineral has, in turn, been accompanied by a steady decrease in the quantity of manufactured thorium nitrate imported. In short, the cheapness of manufactured thorium nitrate in 1910 permitted it to be imported at a price lower than the cost of manufacture from domestic monazite sand; but since thorium nitrate has been manufactured profitably in this country from imported monazite sand the imports of the manufactured salt declined until, in 1916, less than half a ton was imported, whereas about 64 tons was imported seven years earlier. Thus, by reason of its cheapness and of its higher content of thoria foreign crude monazite has practically put an end both to the domestic production of monazite sand and to the importation of thorium nitrate.

The mineral monazite is widespread in its occurrence throughout the world but forms only a very small fraction of 1 per cent of the rock (gneiss, pegmatite, etc.) containing it. On decomposition of the rock, the monazite and other resistant minerals are not attacked chemically but remain behind unaltered and, being much heavier than the products of decomposition, are gradually but slowly concentrated in the residue from the broken-down rock. Locally, river waters will effect a concentration of the heavy minerals into monazite-bearing river sands and gravels. If the ocean encroaches on an area of such decomposed rock, the selective action of the sea waves will still further concentrate the heavier minerals. Seacoast deposits of sand, therefore, contain monazite in higher natural concentration and cover larger areas than river-bed deposits. Even if the percentage of thoria in monazite were constant (which it is not; see p. 232 for analyses), seacoast monazite sands would contain more thoria than river-bed sands on account of their greater content of monazite.

The cheapness of labor in Brazil and India, the two great monazite-producing countries of the world, and the relatively low cost of ocean transportation are further facts which enter into any consideration of the mining of domestic monazite. A third factor is the higher percentage of thoria in the foreign monazite sand. That from Brazil averages 6.3 per cent thoria, that from India 9 per cent, whereas that from this country, according to the published analyses, averages only 4 to 5 per cent (p. 232). Any project to revive the mining of domestic monazite sand must, therefore, consider at least three essential features—the market price of thorium nitrate, the cheapness of imported foreign monazite sand, and the percentage of thoria in the sand.

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PRODUCTION AND IMPORTS.

A statement of the production of monazite sand in the United States is given in the subjoined table. To domestic production are added for comparison the imports of monazite sand, the imports of thorium nitrate, and the price per pound of thorium nitrate. A comparison of domestic production with imports and prices shows that the domestic production declined as the imports of sand increased, and also that the imports of thorium nitrate were affected by both the domestic production and the imports of foreign sand. So much sand was imported in 1916 that only about half a ton of thorium nitrate was brought in, the thorium nitrate used in the manufacture of the incandescent mantles being prepared in this country from imported sand.

The statistics of imports given here and elsewhere in this report are furnished by the Bureau of Foreign and Domestic Commerce, Department of Commerce.

Monazite sand produced in the United States, 1893–1916, and monazite sand and thorium nitrate imported for consumption, 1901–1916.

Year.	Monazite sand produced in the United States.		Imports of monazite sand.		Imports of thorium nitrate.		Price per pound of thorium nitrate.[a]
	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.	
1887	(b)	(b)					[c] $500.00
1893	130,000	$7,600					
1894	546,855	36,193					[d] 221.00
1895	1,573,000	137,150					[d] 58.00
1896	[e] 30,000	1,500					[d] 14.00
1897	44,000	1,980					[f] 7.00
1898	250,776	13,542					[d] 4.00
1899	350,000	20,000					[f] 3.40
1900	908,000	48,805					[f] 3.20
1901	748,736	59,262			(g)	(g)	
1902	802,000	64,160	[h] 190	$12	(g)	(g)	[i] 4.00
1903	862,000	64,630			64,520	$232,155	5.86
1904	744,999	84,838			58,655	249,904	5.98
1905	1,344,418	162,308			52,378	269,504	6.53
1906	846,175	152,312			40,090	139,929	3.78
1907	547,948	65,754			51,441	152,666	4.29
1908	422,646	50,718			65,289	173,239	4.70
1909	541,931	65,032	69,988	8,324	127,833	236,057	3.87
1910	99,301	12,006	453,554	39,699	124,808	219,615	3.10
1911	0	0	705,149	60,542	121,111	238,841	3.00
1912	0	0	556,959	47,334	117,485	225,386	3.00
1913	0	0	817,810	65,848	119,044	230,628	2.73
1914	0	0	770,842	61,595	101,927	239,376	2.98
1915	[j] 36,000	3,600	1,873,971	161,456	67,247	170,268	[k] 4.50
1916	37,872	3,400	2,436,197	188,383	909	3,884	[l] 6.25

[a] The first prices given are only approximate. The prices after 1898 are an average for the year and may likewise be only approximate.

[b] A production of 24,000 pounds in 1887 was reported as having been shipped from Brindletown Creek, Burke County, N. C., but no value was reported, and no other production was reported until 1893.

[c] In 1888 thorium nitrate was quoted at approximately $500 a pound. Pratt, J. H., Zircon, monazite and other minerals, etc.: North Carolina Geol. Econ. Survey Bull. 25, p. 35, 1916.

[d] Molinari, Ettore, General and industrial inorganic chemistry, p. 402, 1912.

[e] Production (exports) of Brazilian monazite sand began in 1895.

[f] Kithil, K. L., Monazite, thorium, and mesothorium: Bur. Mines Tech. Paper 110, p. 28, 1915.

[g] The figures for the fiscal year 1901 are 12,986 pounds, valued at $41,663, and for the fiscal year 1902 they are 10,480 pounds, valued at $34,310. The imports of thorium nitrate do not include the imports of manufactured gas mantles.

[h] Includes thorite.

[i] The prices for 1902 to 1914, inclusive, are taken from the report by Kithil cited above. An average price was taken for those years in which a variation was shown.

[j] The figures of production for 1915 were not received until after publication of the Summary of Mineral Production of the United States for 1915.

[k] The prices for 1915 ranged from $3.75 to $6. See next reference.

[l] The prices for 1916 ranged from $4.75 to $8.50. The figures for 1915 and 1916 were kindly furnished by Dr. Hugo Lieber, 120 Broadway, New York City.

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Thorium oxide and other salts and scrap mantles imported, 1909–1916.

Year.	Thorium oxide and other salts.		Scrap mantles.	
	Quantity (pounds).	Value.	Quantity (pounds).	Value.
1909	17,549	$19,596	.....	$3,926
1910	5,234	8,500	.....	2,194
1911	.....	.....	.....	3,227
1912	.....	.....	.....	1,822
1913	1,763	2,694	12,107	434
1914	763	1,687	52,473	3,099
1915	139	349	.....	.....
1916	4,099	9,487	.....	.....

The duty on imported monazite sand was 6 cents a pound in 1902; on August 6, 1909, the duty was changed to 4 cents a pound; in July, 1913, the duty became 25 per cent ad valorem. Imported thorium nitrate paid 25 per cent duty from 1901 to 1908, 40 per cent in 1909 and until July, 1913, when it was changed back to 25 per cent. Thorium oxide and other salts paid 40 per cent duty until 1913, when it was reduced to 25 per cent. Scrap mantles, or mantle ashes, paid 40 per cent duty until October 4, 1913; since then the duty has been 10 per cent.

WORLD'S PRODUCTION.

The production of monazite sand in the United States, Brazil, and India is given in the following table. These three countries have produced practically all the thorium minerals that have been utilized in the manufacture of thorium nitrate. The monazite and thorite produced in Norway, combined with the very small production in other countries, averages less than 0.1 per cent.

World's production of monazite sand, 1893–1916, in short tons.

Year.	United States.	Brazil.	India.	Total.	Percentage production of the United States.
1893	65	.....	.....	65	100
1894	273	.....	.....	273	100
1895	787	3,307	.....	4,094	19
1896	15	192	.....	207	7
1897	22	249	.....	271	8
1898	125	2,149	.....	2,274	5
1899	175	2,932	.....	3,107	6
1900	454	1,633	.....	2,087	22
1901	374	1,811	.....	2,185	17
1902	401	1,328	.....	1,729	23
1903	431	3,636	.....	4,067	11
1904	372	5,357	.....	5,729	6
1905	672	4,891	.....	5,563	12
1906	423	4,797	.....	5,220	8
1907	274	4,891	.....	5,165	5
1908	211	5,473	.....	5,684	4
1909	271	7,121	.....	7,392	4
1910	50	5,994	.....	6,043	(a)
1911	0	4,064	931	4,996	0
1912	0	3,746	1,271	5,018	0
1913	0	[b] 1,584	1,327	2,911	0
1914	0	[c] 661	1,307	1,968	0
1915	18	[c] 484	1,221	1,723	1
1916	19	.....	1,424	.....	.....

[a] Less than 1 per cent.
[b] To France, Germany, and the United States.
[c] All to the United States.

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LOCALITIES.

UNITED STATES.

The workable deposits of monazite sand in the United States are in North Carolina, South Carolina, and Idaho. In North Carolina deposits of commercial value have been found in Alexander, Burke, Catawba, Caldwell, Cleveland, Gaston, Iredell, Lincoln, McDowell, Polk, and Rutherford counties; in South Carolina in Anderson, Cherokee, Greenville, Laurens, Oconee, Pickens, and Spartanburg counties. The Idaho deposits are around Centerville, Boise County.

These domestic deposits have been repeatedly described and are well summarized in Bulletin 25 of the North Carolina Geological and Economic Survey (1916) and therefore need not be discussed here. No reports of production from the Idaho field have been received in recent years, and the production from the Carolinas has in recent years been very small.

Samples of monazite sand from a locality near Jacksonville, Fla., have been received from several persons. It is reported that a company has undertaken extensive development work at this locality.

BRAZIL.

The deposits of monazite sand in Brazil lie along the coast of the States of Bahia, Espirito Santo, and Rio de Janeiro, from Maranhao in Bahia, south to the State of Rio de Janeiro. Deposits occur also in the sandy beds of rivers of the interior. The following localities are given by Gottschalk:[1]

Praia Massanduba, near Cape Frio, deposits of titaniferous iron containing some monazite; Macaha, 45 miles farther north, a small deposit; at the foot of the Cliffs of Siry, 30 miles north of the southern frontier of the State of Espirito Santo, a reputedly rich bed; at Maratayso Praia, 2 miles farther north, a poor bed; at the foot of Mount Aga, at Piuma, just south of Benevente, two beds not far apart; at Ubu, 4 miles north of Benevente, a better deposit; 2 miles north, at Maimba, and 2 miles farther north, at Miahype, Federal beds with extensive private marginal deposits. Miahype is considered by some persons one of the richest beds in Brazil. Four miles north of this come the southernmost of the Guarapary beds—Rastinga, Canto de Riacho, Praia de Diogo, etc. Nothing occurs for 15 miles northward till Ponto da Fructa and Victoria. Eighteen miles north of Victoria is a deposit at Nova Almeida, and 20 miles farther one at Regencia, described as particularly large. Seventy miles farther north are the Sao Matheus beds. It is said that certain beds still farther north—those of Padro, in the State of Bahia—are constantly being renewed by the wave action of extremely high tides beating upon the clay cliffs. Two other beds in the State of Bahia are mentioned—one at the mouth of the Cahy River and another just north of the River Carahyba. It is said that neither is important.

The coast sands were originally rich enough to be shipped as found, but in later years these rich natural concentrations have been worked out and the sand is now artificially concentrated before being shipped.

The interior deposits are in the sandy beds of rivers of the States of Minas Geraes, Espirito Santo, and Rio de Janeiro. The formation is similar to that of the Carolinas, the stream sands and bottom lands containing about the same proportion of monazite. Locally some of the deposits are much richer.

[1] Gottschalk, A. L. M., Brazilian monazite sands lie in coastal strip: Min. and Eng. World, May 15, 1915.

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The production of monazite sand in Brazil, as based on the exports, is reported to be as follows:

Monazite sand produced (exported) in Brazil, 1895–1916.

Year.	Quantity (short tons).	Value.	Average value per ton.	Year.	Quantity (short tons).	Value.	Average value per ton.
1895	3,307	.....	.....	1906	4,797	$478,961	$100
1896	192	.....	.....	1907	4,891	486,066	99
1897	249	$21,602	$87	1908	5,473	551,744	101
1898	2,149	92,775	43	1909	7,121	704,387	99
1899	2,932	.....	.....	1910	5,994	620,605	104
1900	1,633	165,412	101	1911	4,064	540,688	133
1901	1,811	165,154	91	1912	3,746	528,614	141
1902	1,328	261,141	197	1913	1,584	186,520	118
1903	3,636	360,797	99	1914	661	79,068	120
1904	5,357	529,597	99	1915	484	56,358	117
1905	4,891	486,835	99	1916	.....	.....	.....

Monazite sand exported from Brazil, 1910–1915, in short tons.

By States.

State.	1910	1911	1912	1913	1914	1915
Bahia	757	614	1,347	.....	.....	.....
Espirito Santo	1,322	2,272	2,250	1,574	661	484
Rio de Janeiro	3,915	1,178	149	10	.....	.....
	5,994	4,064	3,746	1,584	661	484

By destinations.

Destination.	1910	1911	1912	1913	1914	1915
Germany	2,906	2,083	2,042	282	.....	.....
France	1,864	1,209	1,041	858	.....	.....
United States	1,213	772	661	441	661	484
Italy	11	.....	.....	.....	.....	.....
Great Britain	.....	.....	1	3	.....	.....
	5,994	4,064	3,746	1,584	661	484

INDIA.

Travancore.—Monazite is widely distributed over the State of Travancore, in the extreme southwestern part of India. The rocks are essentially gneisses and intruded pegmatites. Many of the soils and river sands show monazite, but only in certain naturally concentrated deposits near the seacoast are the deposits of commercial size. The selective action of the sea waves has led to local concentrations of large quantities of monazite in the sands. The monazite sand is further concentrated by artificial means and, until the war, was exported to Germany. The deposits were discovered by a German prospector in 1909, and work was begun by the London Cosmopolitan Mining Corporation in 1911. Actual figures of production are not available for 1916, but they are said to be large.

The following description of the deposits is taken from an article on "Monazite in southern India," in the Mining Journal (London), for August 10, 1912:

Hitherto the chief localities for the mineral monazite have been Brazil and Carolina, in the United States of America. It is not unlikely that in the near future southern

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India will be a serious competitor in the market. The chief locality, one may say almost the only locality, is the native State of Travancore, forming the extreme southern portion of the Presidency of Madras, and separated from British India by the range of hills known as the Western Ghauts.

The deposits brought into public notice in 1909 by Mr. C. W. Schomberg, of the London Cosmopolitan Mining Corporation, occur along the coast on the east and the west, and are somewhat extensive. Starting on the eastern side, north of the Vattokotta Fort, the mineral occurs in isolated patches, but these are not extensive, being confined to brooks and small areas on the shore. The first deposit, which is fairly rich, is about a mile south of the fort, and about 3 miles north of Cape Comorin. The extent, however, is small, being not more than 5 acres. The sand is very fine in texture, the monazite contents rising to sometimes 20 per cent, though the average is much less, depending on the waves. The associated minerals are ilmenite, garnet, zircon, rutile, and a certain amount of quartz. Going southward, immediately north of the Cape, is another deposit, somewhat more extensive but still of the same character as the previous one. These two deposits, together with the periodical accretion due to the action of waves, will yield a few thousand tons of monazite.

Turning to the west coast, the southernmost deposit is an extensive one, running from Kadiapatnam north of Muttam to the seaport of Colachel, for nearly 4 miles in length; the breadth varies from half a mile to a quarter and less. The extreme southern portion is very rich in monazite, the percentage rising to nearly 50 or more. The depth of the deposit is not known; probably it is not much, as one often sees bosses of granites, gneisses, and charnockites rising above. Possibly the deposit is laid in the hollows formed by these rocks. It is estimated by the Geological Survey of India that this contains at least 1,800 tons; this is a low estimate, as it is expected that this patch will last at least 20 years, the output being 1,200 tons a year. This deposit gains considerable importance, being easily worked at and being so near the port Colachel. Northward there is not any patch of monazite sand till we come to about 8 miles south of Trevandrum, the capital of the State. Here it is about a mile long, but it is only a few yards in breadth, and the sand is not very rich either. The next deposit of any importance is the one a little north of Anjengo, passing by Warkala to near Edava. The sand is rich generally, but in certain parts it is extremely poor. Farther north there is a deposit of some extent near Quilon. All these deposits are flat coastal deposits, not differing from other parts in other respects. In all these monazite is associated with ilmenite usually, but invariably garnet, rutile, and zircon, with a varying amount of quartz, and broken shells are present.

The mineral found in these deposits has been traced by Mr. E. Masillamani, the State geologist, to the pegmatites, which are everywhere seen to cut through the gneisses, granulites, charnockites, and other igneous rocks. In these the mineral is usually in intimate association with ilmenite, but he has pointed out that this is not invariably so, as instances are known where ilmenite is entirely absent, giving way to mica; in fact, the pegmatite becomes a mica-monazite pegmatite, the other constituents, quartz and feldspar, being insignificant. Again, the mineral is seen in close intimacy with graphite. Some specimens of graphite are fittingly described as being charged with monazite. Dr. Derby, of Rio de Janeiro, is of opinion that graphite almost always contains monazite or rutile included in it. The pegmatites by decomposition set free monazite, which is carried by streams to the seashore. Hence it is but natural that small pocket deposits should be found inland; but these are insignificant. All around the coast are found a series of grits and sandstones, locally known as the Warkalli beds; these also occasionally contain monazite, which was necessarily derived from the decomposition of the pegmatites.

The production of monazite sand in Travancore, India, began in 1911, and until the war the sand was exported to Hamburg, Germany. Since then increasing imports have been brought to this country.

Monazite sand produced (exported) in Travancore, India, 1911–1916.

Year.	Quantity (short tons).	Value.	Average value per ton.	Year.	Quantity (short tons).	Value.	Average value per ton.
1911	931	$117,010	$126	1914	1,307	$201,527	$154
1912	1,271	201,566	159	1915	1,221	161,753	132
1913	1,327	204,451	154	1916	1,424	183,535	129

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Mysore.—Monazite occurs in Mysore, but no naturally concentrated deposits of value have been found[1]. Monazite from decomposed pegmatite carried only 2.25 per cent of thoria.

OTHER LOCALITIES.

Malay Peninsula.—In the Malay Peninsula the alluvial deposits of tin ore contain varying proportions of monazite in the "amang," the residue of heavy minerals, supposed to be worthless, separated from the alluvial tin ores. This monazite, in a pure state, has yielded on analysis of different samples, 5.30, 8.38, and 8.7 per cent, respectively, of thoria, and is therefore a valuable by-product. The different constituents of the alluvial tin deposits can be separated by a combination of hydraulic, mechanical, and electromagnetic processes. So far as known there has been no commercial production from this field.

Western Australia.—Certain alluvial deposits in Western Australia contain abundant monazite, tin ore, and the rare-earth minerals fergusonite, euxenite, and gadolinite. The monazite from Cooglegong is in small pebbles of an average weight of about one-fiftieth of an ounce. A sample of the sand contained 80 per cent monazite and yielded 3.46 per cent thoria. The monazite sand from the residue obtained by resluicing low-grade alluvial tin ore contained 26 per cent monazite. The individual pebbles of monazite yielded a little more than 5 per cent thoria.

Southern Norway.—The pegmatites of southern Norway contain large crystals and masses of monazite, which are saved by the feldspar miners and sold as a by-product of the quarries. It has been stated that the annual quantity of monazite so obtained and sold has never been more than a ton for any one year.

USES.

The thorium extracted from thorium minerals is used in the form of nitrate in the manufacture of incandescent gas mantles. The fabric of the mantles is made of cotton, ramie fiber, or artificial silk, which is impregnated with a solution of thorium nitrate, then dried and burnt off. The resulting thoria, when heated, emits an intense white light. A mixture of 99 per cent thoria with about 1 per cent ceria gives the brightest light. From 250 to 500 mantles are produced from 1 pound of thorium nitrate. The world's annual consumption of incandescent gas mantles is about a third of a billion. A small quantity of thoria mixed with a little ceria is being used as the illuminating material in certain searchlights and automobile headlights. Thorium compounds form a portion of some magnesium flashlight powders, and the metal thorium, with other rare-earth metals, is alloyed with tungsten, making very ductile filaments for electric lamps.

Several other products are obtained from the monazite sand, but only a very slight use has been found for them. From the monazite itself thousands of tons of cerium, lanthanum, neodymium, and praesodymium oxides have been prepared. Uranium, radium, and mesothorium are also present in monazite. Mesothorium has uses

[1] Smeeth, W. F., and Iyengar, P. S., Mineral resources of Mysore: Mysore State Dept. Mines and Geology, Bull. 7, pp. 191-192, 1916.

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similar to those of radium, and although the percentage of mesothorium in monazite is exceedingly small, its very high value might pay for its recovery as a by-product. A small quantity of cerium nitrate is added to the thorium nitrate used in the gas mantles. Some cerium is used in pyrophoric alloys, and a little, as oxalate, is used in medicine. The neodymium and praesodymium salts form the basis of the indelible brand placed upon the gas mantles.

SOURCES OF THORIUM.

RELATIVE IMPORTANCE.

Monazite sand has furnished more than 99 per cent of the crude material from which thoria has been obtained. Several other thorium minerals have been produced, however, and although the total output of them is small, they are much richer in thorium than monazite and would prove of very great value if found in deposits of commercial size. In addition to the minerals thorite, thorianite, auerlite, and several others, broken or scrap mantles which consist essentially of thoria are valuable, as the thoria can be changed to the nitrate form and used over again. From 1910 to 1914, inclusive, scrap mantles valued at $14,702 were imported into this country.

MONAZITE.

GENERAL DESCRIPTION.

Monazite is essentially a phosphate of cerium, lanthanum, and didymium, including small and varying quantities of thorium, silicon, and other elements. The mineral is yellow, varying in shade and tint from a light greenish yellow to dark honey-brown; it is somewhat translucent to opaque, and it is characterized by a resinous or greasy luster. It shows no distinct cleavage, and is brittle, breaking with an uneven fracture. In the original rock it may show sharp edges and plane crystal faces, but as found in sand it is in rounded grains, intimately mixed with other heavy and resistant minerals, the most abundant of which are zircon, magnetite, ilmenite, and garnet.

The monazite sands as found usually have to be concentrated, as the sands of this country usually carry less than 50 per cent monazite.

ANALYSES.

A compilation of analyses of the mineral monazite—that is, the pure, selected mineral—has been made to serve as a basis for comparison of the value of monazite from different localities. The percentage of thoria present in the sand from which this monazite was selected can be obtained by multiplying the percentage of thoria in the pure mineral by the percentage of monazite in the sand.

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Analyses of samples of monazite from the United States.

	1	2	3	4	5	6	7
ThO_2	6.49	1.48	1.22	1.43	2.32	1.19	7.00
Ce_2O_3	31.38	37.26	54.03	32.93	[a]65.32	[c]61.77	34.50
$(La, Di, Yt)_2O_3$	30.88	31.60		[b]25.54			28.80
P_2O_5	29.28	29.32	23.43	18.38	28.16	26.05	26.00
SiO_2	1.40	.32	1.60	6.40	3.20	1.45	2.00
ZrO_2			3.25				.70
TiO_2				4.67	.61	1.40	.90
Fe_2O_3			5.58	7.83	0	.65	
Al_2O_3			2.49	1.62	0	.15	
CaO				1.20	0		.70
H_2O	.20	.17					
Miscellaneous			[c]7.74			[d]6.39	
	99.63	100.15	99.34	100.00	99.61	99.05	100.60

[a] Including ZrO_2 and BeO.
[b] Including ZrO_2, BeO, and Ta_2O_5.
[c] Including 4.12 per cent $(Cb, Ta)_2O_5$ and 3.62 per cent FeO.
[d] Ta_2O_5.
1. Sand from Brindletown district, Burke County, N. C. Penfield, S. L., Am. Jour. Sci., 3d ser., vol. 24, p. 252, 1882.
2. Alexander County, N. C., 3 miles east of the hiddenite mine. Penfield, S. L., and Sperry, E. S. Am. Jour. Sci., 3d ser., vol. 36, pp. 317–331, 1888.
3. "Carolina." (Probably Belwood, N. C.) Monazite separated from sand containing 78.39 per cent monazite. Tschernik, G. P. Acad. Imp. Sci. St. Petersburg Bull., vol. 2, pp. 243–254, 1908.
4. Monazite sand from Burke, N. C. Not pure monazite. Glaser, C., Estimation of thoria; chemical analysis of monazite sand: Am. Chem. Soc. Jour., vol. 18, pp. 782–798, 1896.
5. Nearly pure monazite, from Shelby, N. C. Idem.
6. Nearly pure monazite, from Belwood, N. C. Idem.
7. From South Carolina. Tschernik, G. P., op. cit.

A rather high percentage of thoria in North Carolina monazite is reported by Kress and Metzger,[1] who give the thoria content for four selected samples of monazite as 7.49–8.07, 5.57–5.79, 6.10–6.40, and 5.72–5.99 per cent. Monazite from Madison County, N. C., is stated to carry 5.06 per cent of thoria.

Analyses of samples of monazite from Brazil.

	1	2	3	4	5	6
ThO_2	9.23	10.05	1.09	6.06	6.50	6.49
Ce_2O_3	31.21	32.14	32.46	62.92	62.10	31.28
$(La, Di)_2O_3$		25.99	36.02			30.88
P_2O_5	28.36	25.51	29.18	28.50	28.46	29.28
SiO_2	10.14	2.63		.75	.64	1.40
ZrO_2	5.74	.60				
TiO_2	2.62					
Fe_2O_3	4.22	1.79	.61	.97	1.50	
Al_2O_3	.32	.84		.10	.08	
CaO	1.11	.20	.10	.21	.30	
H_2O		.92		.38	.64	.20
Ta_2O_5	1.16					
	94.11	100.67	99.46	99.89	100.22	99.53

1. Monazite from river bed, in large pieces weighing as much as 2 pounds; derived from pegmatite. Southern Serra dos Aymores, Espirito Santo. Freise, F., Zeitschr. prakt. Geologie, vol. 18, pp. 123–124, 1910.
2. From river sands of Rio Paraguassir in Bahia, Bandeiro do Mello. Hussak, E., and Rettinger, J., Zeitschr. Kryst. Min., vol. 37, pp. 550–579, 1903.
3. Sand from Bandeirinha, near Diamantina, Minas Geraes. Idem.
4. Espirito Santo, Johnstone, S. J., Soc. Chem. Industry Jour., vol. 33, pp. 55–59, 1914.
5. Alcobaca, Borhia. Idem.
6. Brazilian monazite. Analysis furnished by F. H. Lee. Gottschalk, A. L. M., Min. and Eng. World, May 15, 1915.

[1] Kress, O., and Metzger, F. J., Does thorium exist as thorium silicate in monazite?: Am. Chem. Soc. Jour., vol. 31, pp. 640–652, 1909.

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Analyses of samples of monazite from India and Ceylon.

	1	2	3	4	5	6
ThO_2	10.22	8.65	10.75	10.29	9.49	7.90
Ce_2O_3	31.90 } 61.73		26.71	27.37	27.15 }	56.50
$(La, Di)_2O_3$	28.46		31.52	32.27	33.52	
P_2O_5	26.82	26.50	24.61	27.67	26.12	26.80
SiO_2	.90	1.00	2.47	1.03	1.67	1.92
Fe_2O_3	1.50	1.09	1.09	.81	.87	1.40
Al_2O_3	.17	.12	.70	.17	.17	.13
CaO	.20	.13	.85	.41	.45	.27
H_2O	.46	.45	.93	.20	.48	2.20
U_3O_8						2.66
	100.63	99.67	99.63	100.22	99.92	99.78

Johnstone, S. J., Monazites from some new localities: Jour. Chem. Industry, vol. 33, pp. 55–59, 1914.
1. Sand from Travancore, India.
2. Isolated from a concentrate from Travancore, India.
3. From sand from Niriellaganga, Ceylon.
4. Monazite pebble from Ratnapura, Ceylon.
5. Monazite pebble from Muladiwanella Durayakanda, Gilimale, Ceylon.
6. Washed from pegmatite containing 100 grams monazite per metric ton (0.01 per cent) from Rifle-Range Stream, Moon Plains, Ceylon: Imp. Inst. Bull., vol. 14, p. 349, 1916.

Analyses of samples of monazite from the Malay Peninsula and Australia.

	1	2	3	4	5	6
ThO_2	8.38	3.40	3.53	9.41	5.03	3.80
Ce_2O_3	25.46	33.74 } 66.45		62.82	{ 33.06	31.10
$(La, Di)_2O_3$	35.52	33.44			{ 30.35	34.30
P_2O_5	23.92	26.58	27.87	23.71	26.70	26.89
SiO_2	.92	1.45	1.08	2.20	1.22	1.96
Fe_2O_3	2.78	.65	.64 } 1.13		{ 2.21	.42
Al_2O_3	.84	.03	.07		{ .44	.64
CaO	.61	.33	.17	.29	a 1.11	.34
H_2O	1.28	.94	.52	.94	.59	.58
	99.71	100.56	100.33	100.50	100.71	100.03

a CaO, 0.90; MgO, 0.21.

1. Concentrated monazite from the Sempang Tin Co., Pahang. Occurence of monazite in the tin-bearing alluvium of the Malay Peninsula: Imp. Inst. Bull., vol. 4, pp. 301–309, 1906.
2. Isolated from concentrate, Puchong, Babi, River Kenring, Perak. Johnstone, S. J., Monazites from some new localities: Jour. Chem. Industry, vol. 33, pp. 55–59, 1914.
3. Isolated from concentrate, Kulim, Kedah. Idem.
4. Kelantan. Idem.
5. Forty pebbles from Moolyella, Western Australia. Simpson, E. S., The occurrence of monazite at Cooglegong and Moolyella: Western Australia, Geol. Survey Bull. 48, 1913,.
6. Single crystal from Cooglegong, Western Australia. Idem.

PERCENTAGE OF THORIA IN MONAZITE SANDS.

Monazite sands contain many other minerals besides monazite, chiefly zircon, ilmenite, garnet, magnetite, and quartz, but also cassiterite, xenotime, rutile, columbite, tantalite, andalusite, etc. The value of the monazite sand depends on the percentage of the mineral monazite, and the sands as found are further concentrated to contain at least 90 per cent of the pure mineral.

Recent figures giving the percentage of thoria in monazite sand from the United States are not available, but older analyses of sand containing about two-thirds monazite report the following percentages of thoria (ThO_2) in the sand from North Carolina: 0.13, 0.18, 0.23, 0.26, 0.29, 0.40, 1.27, 1.75, 1.93, 2.15, 2.25, 2.48, 3.40, 4.84, 5.11, 5.19, 5.87, 6.26, 6.30, 6.54, the average of these 18 analyses being 2.60 per cent. A sample from Brindletown, N. C., analyzed by W. F. Hillebrand, contained 4.3 per cent thoria.

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Artificially concentrated monazite sand from the Centerville region, Idaho, yielded from 2.41 to 4.60 per cent thoria. Another analysis gave 5.2 per cent for the pure mineral, or 4.94 per cent ThO_2 for a 95 per cent sand. Monazite sand from the Musselshell district, Idaho, containing 31.8 per cent monazite gave 0.88 per cent thoria, and sand containing 55.36 per cent monazite gave 1.85 per cent thoria. A sample from Placerville, Idaho, contained 1.2 per cent thoria. Sand from Bighole River in Beaverhead County, Mont., containing 65 per cent monazite, gave 1.69 per cent thoria.

The Brazilian sand, from the seacoast, as marketed, is stated to run about 92 per cent monazite and to contain from 5 to 7 per cent thoria or an average content of 6.3 per cent. The inland deposits are said to be slightly lower in their thoria content than the seacoast sand, and to run from 4 to 5.7 per cent thoria.

The India sand, as found, carries as much as 46 per cent of monazite, the remainder being chiefly ilmenite and zircon. A somewhat concentrated sample of the sand, as marketed in London, contained 62 per cent monazite, 26 per cent ilmenite (chiefly), and 11 per cent zircon (chiefly), and yielded from 5 to 6 per cent thoria. Analyses of Indian sands (from 90 to 100 per cent monazite) yielded the following percentages of thoria: 4.8, 6.0, 8.5, 8.65, 8.70, 8.7, 8.87, 9.2, 10.08, 10.22. This India sand, as marketed in the United States, runs 90 per cent monazite and yields 9 per cent thoria.

The monazite from Ceylon, not produced on a commercial scale, is also rich in thoria. Sand with 48 per cent monazite yielded 4.15 per cent thoria, another with 96 per cent monazite yielded 8.39 per cent thoria. Artificial concentrations from pegmatite, with from 45 to 87 per cent monazite, yielded from 5 to 7.3 per cent thoria.

The Malayan sands are unique in their high content of cassiterite, which ranges up to 65 per cent. The monazite in these sands runs from 1 to 58 per cent.

THORITE.

The silicate of thorium, or thorite, is usually massive and disseminated through the pegmatite rock in irregular, compact masses. Rarely crystals, similar in shape to those of zircon, are found. Thorite is more or less opaque and of a dark-brown or black color, with a glassy luster and shell-like fracture. The luster of the altered forms is more resinous or greasy. Very rarely clear crystals are found, and these are of a yellow or orange color and are known as orangite. The mineral, as found, is generally impure and contains considerable water. The formula of the mineral ($ThSiO_4$) calls for 81.5 per cent ThO_2, but this value is not reached by the mineral as found. Analyses have shown the following percentages of thoria (ThO_2): 49, 50, 52, 57, 58, 59, 66, 69, 71, 72, 73, and 74.

Thorite has been found at numerous places, but has been produced in small quantities for consumption only in Norway and in Ceylon. The mineral occurs with feldspar in the syenite pegmatites on the islands of the Langesunder Fjord, in southern Norway. Some masses of the mineral weighed over 2 pounds. When first found, a pound of thorite brought about $49, so that it paid to collect the isolated masses from the feldspar quarries. The entire pegmatite, on being sampled,

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yielded only a small fraction of 1 per cent for its thorite content, so that the entire pegmatite could not be crushed and worked, only the portions rich in thorite being exploited for that mineral. The development of the Brazilian and Carolina deposits of monazite stopped thorite mining in Norway. No figures of production of thorite from Norway are available, but it has been stated that the production of monazite, found with the thorite as large, individual crystals and masses, probably did not exceed 2,000 pounds in any one year. In 1905 a total of 112 pounds of thorite, valued at $97, and in 1907 a total of 447 pounds, valued at $146, were exported from Ceylon.

AUERLITE.

Auerlite is a dull yellowish-white to reddish mineral, closely related to thorite. It was found at the Freeman zircon mine near Zirconia, Henderson County, N. C. In composition it is essentially a silicate of thorium containing 70 per cent ThO_2. Several pounds has been obtained, and it is thought that a considerable output could be produced by further exploitation.

THORIANITE.

A black mineral from the gem washings of Ceylon, found to be very rich in thoria, and consisting chiefly of that oxide, with a little uranium, was named thorianite. Its analyses and relations to uraninite indicate that it has the formula ThO_2, being probably isomorphous with uraninite UO_2. Consequently the natural occurrences of the mineral show slight and varying amounts of uranium oxide, the percentages of thorium oxide reported in the analyses of thorianite being 59, 62, 63, 65, 67, 71, 72, 74, 76, 77, 79, and 93.

Thorianite has been reported from the United States, Madagascar, and Russia, as well as from Ceylon, but only in Ceylon has it been produced commercially.

In 1904 thorianite was discovered in the refuse from gem washings near Belangoda, Ceylon. The high percentage of thoria in the mineral gave it sufficient commercial value to induce considerable exploration for deposits of the mineral. The rich placer deposits were soon exhausted, and after 1907 production of thorianite on a commercial scale practically ceased, except in the year 1911. It is considered improbable that new placer deposits rich enough to be worked will be found in Ceylon. The richness of the detrital deposits that have been worked was due not to the richness of the pegmatites, but to the large aggregate area of thorianite-bearing pegmatite outcrops. Attempts to exploit the thorianite-bearing pegmatites have all failed, as the percentage of thorium mineral in the pegmatite, from 0.001 to 0.003, is too small. An unusually rich pegmatite, which contained segregations of thorianite, yielded an average of 6 pounds of thorianite to the ton (0.3 per cent); other samples yielded 8 ounces of thorianite to the ton (0.025 per cent); and another pegmatite averaged only half an ounce to the ton (0.0016 per cent).

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Thorianite produced in Ceylon, 1904–1911.

Year.	Quantity.	Value.	Average price per pound.	Year.	Quantity.	Value.	Average price per pound.
	Pounds.				*Pounds.*		
1904	a 3,000	a $3,000	.....	1908	178	a $274	.....
1905	20,049	24,333	$1.23	1909	224	a 345	.....
1906	5,825	8,030	1.38	1910	0	.....	.....
1907	1,000	1,541	1.54	1911	8,818	60,393	$6.85

a Estimated.

When first found thorianite was valued at about a dollar a pound. The value soon increased, and in 1911, the last year of recorded production, it was nearly $7 a pound. To-day the mineral is quoted at about $7 a pound, or $12 a pound of contained thoria.

The mineral has been identified in the black slimes from a gold placer deposit on River Boshagoch, Transbaikal, Siberia.[1] The accompanying monazite contained 8.2 per cent thoria.

OTHER MINERALS.

A number of other minerals contain thoria in large proportion, and deposits of such minerals would have a very great value. Thorogummite from Texas contains 41 per cent thoria; that from Wodgina, Western Australia, 24 per cent. Mackintoshite from Texas carries 45 per cent, and that from Wodgina 25 per cent. Pilbarite from Wodgina has 31 per cent thoria. Other black or blackish-brown heavy minerals with a greasy or pitchlike luster, such as fergusonite, zirkelite, uraninite, yttrochrasite, and yttrialite, are likely to contain small quantities of thoria.

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FULLER'S EARTH.[1]

By JEFFERSON MIDDLETON.

GENERAL CONDITIONS.

The fuller's earth industry showed considerable progress in 1916, and the quantity, value, and average price per ton of the product sold in that year were the largest ever recorded by the United States Geological Survey. The increase in quantity was 19,921 short tons, or 42 per cent, and in value $217,732, or 45 per cent, over 1915, the previous leading year. Almost from the beginning of the industry in this country the quantity and value and the average price per ton of the domestic product have exceeded those of the imports. The quantity and the value of the earth produced in the United States in 1916 were more than four times as great as those of the earth imported, and the average price per ton of the domestic earth was $2.11 more than that of the imported earth. Notwithstanding a continued decrease in imports, the apparent consumption—production plus imports—increased from 57,222 short tons in 1913 to 84,623 in 1916. The domestic fuller's earth formed 80 per cent of the consumption in 1916 and 67 per cent in 1913.

OCCURRENCE.

Fuller's earth has been reported in Alabama, Arizona, Arkansas, California, Colorado, Florida, Georgia, Massachusetts, Minnesota, Mississippi, Missouri, Nebraska, New York, South Carolina, South Dakota, Texas, Utah, and Virginia; but it was mined and marketed in 1916 in only six States—Arkansas, California, Florida, Georgia, Massachusetts, and Texas—the same as in 1915. The South produced practically all the domestic fuller's earth marketed in 1916.

It is reported to the Geological Survey by Mr. John P. Herrman, of St. Louis, Mo., that in 1885 he discovered a deposit of fuller's earth in Dallas County, Mo., but that he has never developed it because of its remoteness from rail transportation.

USES.

Fuller's earth obtains its name from its original use in fulling cloth. Little domestic earth is now used in this country for that purpose, the principal uses being in bleaching, clarifying, or filtering fats, greases, and oils. It is also used in the manufacture of pigments for printing wall papers, in detecting certain coloring matters in some food products, and as a substitute for talcum powder.[2]

[1] The tables of production in this report were prepared by Miss L. M. Jones, and the table of imports by Mr. J. A. Dorsey.

[2] Bur. Mines Bull. 71, p. 19, 1913.

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PRODUCTION.

The growth of the industry since 1895, when it assumed commercial importance, is shown in the first of the following tables. The steady growth of the industry is evident, the production being nearly 10 times as great and the value 17 times as great in 1916 as in 1895. The lowest price per ton ($5.72) was in 1904 and the average price per ton in 1916, $10.42, was the highest attained for domestic earth and was 21 cents higher than in 1915.

Fuller's earth produced and marketed in the United States, 1895–1916.

Year.	Quantity (short tons).	Value.	Average price per ton.	Year.	Quantity (short tons).	Value.	Average price per ton.
1895	6,900	$41,400	$6.00	1906	32,040	$265,400	$8.28
1896	9,872	59,360	6.01	1907	32,851	291,773	8.88
1897	17,113	112,272	6.56	1908	29,714	278,367	9.37
1898	14,860	106,500	7.17	1909	33,486	301,604	9.01
1899	12,381	79,644	6.43	1910	32,822	293,709	8.95
1900	9,698	67,535	6.96	1911	40,697	383,124	9.41
1901	14,112	96,835	6.86	1912	32,715	305,522	9.34
1902	11,492	98,144	8.54	1913	38,594	369,750	9.58
1903	20,693	190,277	9.20	1914	40,981	403,646	9.85
1904	29,480	168,500	5.72	1915	47,901	489,219	10.21
1905	25,178	214,497	8.52	1916	67,822	706,951	10.42

Fuller's earth produced and marketed in the United States, 1915–1916.

	1915				1916			
	Number of operators.	Quantity (short tons).	Value.	Average price per ton.	Number of operators.	Quantity (short tons).	Value.	Average price per ton.
Florida, Georgia, and Massachusetts	7	45,941	$470,648	$10.24	7	66,311	$690,598	$10.41
Arkansas, California, and Texas	5	1,960	18,571	9.48	3	1,511	16,353	10.82
	12	47,901	489,219	10.21	10	67,822	706,951	10.42

The small number of producers makes it impossible to publish totals for some States without disclosing confidential reports; consequently the distribution of output is grouped as above. The eastern section continues to produce by far the larger part of the fuller's earth marketed, its 7 operators reporting approximately 98 per cent of the quantity and value of the entire output in 1916. Named in the order of their rank, the producing States were Florida, Georgia, Arkansas, Massachusetts, Texas, and California.

THE FULLER'S EARTH INDUSTRY.

Arkansas.—Only one mine was reported in operation in Arkansas in 1916; that of John Olsen, at Klondyke, Saline County. The earth from this mine is used for refining edible oils and animal fats.

California.—In California, one operator reported sales in 1916—a decrease of one operator from 1915. California fuller's earth is used in refining mineral and vegetable oils and animal fats. Notwithstanding the large production of petroleum in California, there ap-

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pears to be only a small quantity of local fuller's earth used in refining petroleum. There are many deposits in the State that could be easily made available for this purpose, should the demand justify their development.

Florida.—Florida was the leading State in 1916, as it has been since the beginning of the industry in this country, and reported 80 per cent of the total quantity and value. The average price per ton of Florida earth marketed in 1916 was $10.62, compared with $10.36 in 1915. The Florida earth is used principally in refining mineral oils.

Georgia.—There are two operators in Georgia, both of whom were active in 1916 and reported business good. Georgia earth is used in refining mineral, animal, and vegetable oils.

Massachusetts.—Only one firm has produced fuller's earth in Massachusetts for several years.

Texas.—One operator reported sales of fuller's earth in 1916. This earth is used in filtering mineral and vegetable oils and chemicals, and in the manufacture of paint. There has been considerable activity in Texas in prospecting, and earths that appear to be of high quality have been discovered.

IMPORTS.

The imports of fuller's earth for consumption in 1916 continued to decline. The decrease in quantity was 14 per cent and in value 8 per cent. The average price per ton of imported earth was 47 cents higher than in 1915. The imports are nearly all (93 per cent in 1916) of wrought or manufactured earth.

Fuller's earth imported for consumption in the United States, 1907–1916.

Year.	Unwrought or unmanufactured.			Wrought or manufactured.			Total.		
	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.
1907	2,490	$16,833	$6.76	13,916	$105,388	$7.57	16,406	$122,221	$7.45
1908	2,363	16,242	6.87	9,803	77,171	7.87	12,166	93,413	7.68
1909	1,802	12,492	6.93	10,950	88,659	8.10	12,752	101,151	7.93
1910	2,160	14,399	6.67	14,427	118,146	8.19	16,857	132,545	7.86
1911	1,881	10,877	5.78	16,343	132,717	8.12	18,224	143,594	7.88
1912	1,970	11,619	5.90	17,139	133,718	7.80	19,109	145,337	7.61
1913	1,916	12,344	6.44	16,712	133,657	8.00	18,628	146,001	7.84
1914	1,468	9,283	6.32	23,509	185,800	7.90	24,977	195,083	7.81
1915	850	5,176	6.09	18,591	147,317	7.92	19,441	152,493	7.84
1916	1,132	7,742	6.84	15,669	131,922	8.42	16,801	139,664	8.31

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BARIUM.

By JAMES M. HILL.[1]

INTRODUCTION.

The barium industry in the United States has shown a remarkable growth since 1913 and in 1916 for the first time the value of the domestic crude barytes marketed in the United States exceeded $1,000,000. A domestic industry for the manufacture of barium chemicals has been established and put on a firm foundation in the last two years, and the manufacture of lithopone and ground barytes has been further expanded. The value of barium products of domestic manufacture made in 1916 was more than $8,500,000.

CRUDE BARYTES.

PRODUCTION.

There are many changes to be noted in the industry of mining domestic barytes, as will be seen from the following table. The most important of these was the shifting of the largest State output from Missouri to Georgia. Of more importance to the Western States was the entrance of Colorado and Nevada into the list of producing States. A large increase in output of barytes from all States is shown in the total production for the country, approximately 222,000 short tons, valued at $1,011,000, an increase of 104 per cent in quantity and 165 per cent in value over the output in 1915. The increase in value is in part due to an increase of about 30 per cent in the average price paid for crude barytes in 1916.

Crude barytes marketed in the United States, 1914–1916.

State.	1914			1915			1916		
	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.
Alabama	(a)	(a)		(a)	(a)		7,631	$27,198	$3.56
Colorado							481	3,005	6.25
Georgia	(a)	(a)		31,027	$102,825	$3.31	104,784	401,295	3.83
Kentucky	(a)	(a)		7,753	28,427	3.67	11,068	54,995	4.97
Missouri	33,317	$112,231	$3.37	39,113	158,597	4.05	58,223	365,111	6.27
North Carolina	(a)	(a)		(a)	(a)		878	3,246	3.70
Tennessee	10,113	16,273	1.61	25,074	71,390	2.85	32,416	123,986	3.85
Other States [b]	9,317	27,143	2.91	5,580	19,793	3.55	6,471	32,396	5.01
	52,747	155,647	2.95	108,547	381,032	3.51	221,952	1,011,232	4.56

[a] Included in "Other States."
[b] Includes, 1914: Alabama, California, Georgia, Kentucky, North Carolina, South Carolina, and Virginia; 1915: Alabama, Alaska, California, North Carolina, South Carolina, and Virginia; 1916: California, Nevada, South Carolina, and Virginia.

[1] The statistical data in this report were prepared by Miss L. M. Jones.

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In view of the remarkable increase in output of crude barytes in the last two years, the following table showing the quantity of barytes mined and sold in the United States since 1880 is of interest. It shows what has been done in one industry toward making the United States independent of foreign crude materials. The average production for the 14 years from 1900 to 1913, inclusive, was 53,378 short tons a year, less than half of the production in 1915 and less than a quarter of the production in 1916. The production of crude barytes in 1915 and 1916, the two war years, when little German barytes was received in the United States, was 330,499 short tons, or 20 per cent of the total quantity of barytes mined in the United States since 1880.

Crude barytes produced and sold in the United States, 1880–1916.

	Short tons.		Short tons.		Short tons.
1880	22,400	1893	28,970	1906	50,231
1881	22,400	1894	23,335	1907	89,621
1882	22,400	1895	21,529	1908	38,527
1883	30,240	1896	17,068	1909	61,945
1884	28,000	1897	26,042	1910	42,975
1885	16,800	1898	31,306	1911	38,445
1886	11,200	1899	41,894	1912	37,478
1887	16,800	1900	67,680	1913	45,298
1888	22,400	1901	49,070	1914	52,747
1889	21,460	1902	61,668	1915	108,547
1890	21,911	1903	50,397	1916	221,952
1891	31,069	1904	65,727		
1892	32,108	1905	48,235		1,619,875

STOCKS.

There were apparently about 10,900 short tons of barytes remaining in stock in the hands of mine operators on December 31, 1916, as compared with approximately 7,500 short tons on December 31, 1915. These figures do not include stocks held by makers of barium products, as the barytes held by these companies has entered the market and is, therefore, included in the statement of marketed production of barytes. The largest stocks reported to the Geological Survey in 1916 were held at mines in South Carolina and Tennessee. In general, barytes is marketed as quickly as possible, and this was particularly the case in 1916 owing to the high prices received; but car shortage and in some of the States railroad embargoes made it impossible for some operators to market their product.

IMPORTS.

The imports of crude barytes, in large part from German sources, ranged from 1910 to 1913 between 20,000 and 35,000 short tons, the average for the three years, 1911–1913, inclusive, being 27,413 short tons. The increase in imports in 1913, as shown in the following table, would probably have been duplicated in 1914 except for the European war, as eastern makers of lithopone were using German barytes because of lower cost due to cheaper ocean transportation.

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Crude barytes imported for consumption, 1911–1916.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1911	20,214	$36,643	1914	24,423	$46,782
1912	26,186	52,467	1915	2,504	4,877
1913	35,840	61,409	1916	17	245

CONSUMPTION.

The apparent consumption of crude barytes in the United States during 1916 increased practically 100 per cent over the consumption in 1915 and 216 per cent over the average consumption of 70,158 short tons for the years 1911–1914, inclusive, as will be seen from the following table:

Apparent consumption of crude barytes, 1911–1916, in short tons.

Year.	Sales of domestic barytes.	Imports for consumption.	Apparent consumption.
1911	38,445	20,214	58,659
1912	37,478	26,186	63,664
1913	45,298	35,840	81,138
1914	52,747	24,423	77,170
1915	108,547	2,504	111,051
1916	221,952	17	221,969

This great increase in domestic consumption of barytes in 1915–16 was in large part due to the establishment of a barium chemicals industry in the United States, but was also due to increased manufacture of lithopone and to the greater use of ground barytes, particularly in the rubber industry. As indicative of the quantities consumed in the various industries, the accompanying table is instructive. It will be noted that the total quantity of crude barytes consumed by the three most important industries represented was less than the reported marketed production by 36,264 short tons. This discrepancy is believed to be due largely to accumulated stocks at the plants of the manufacturers of finished barium products, but may be due in part to consumption of small quantities of crude barytes in industries not circularized or to losses in handling and transportation.

Crude barytes used in the manufacture of barium products, 1915–16, in short tons.

Year.	For barium chemicals.	For ground barytes.	For lithopone.	Total.
1915	10,216	53,903	44,503	108,622
1916	38,283	75,507	71,898	185,688

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MARKET AND PRICE.

Prior to 1914 practically the sole market for crude barytes was centered at St. Louis, Mo., and the central-eastern Atlantic ports, especially Philadelphia. The St. Louis market was practically limited to barytes of the grade used for the preparation of ground and floated barytes. The eastern market included also barytes for the manufacture of lithopone and some chemicals and was partly supplied by domestic barytes but largely by German barytes, which could be obtained at lower cost than the domestic product. In 1915 lithopone plants were built in the vicinity of Chicago.

The situation of plants consuming the largest quantity of crude barytes for the manufacture of lithopone and barium chemicals in the East is apparently responsible for the shifting of greatest State production from Missouri to Georgia, as naturally these industries get their raw products with as low charges for transportation as possible.

The output of small mines is sold generally to local dealers who, in turn, sell to the larger buyers. Thus in the Southern States much of the barytes produced by small operators is eventually sold through Thompson-Weinman & Co., of Cartersville, Ga., and in Missouri the consumers appear to deal more often with Nulsen, Klein & Krausse Manufacturing Co., or J. C. Finck Mineral & Milling Co., of St. Louis, or Point Milling & Manufacturing Co., of Mineral Point, Mo.

The prices received for crude barytes, f. o. b. cars at the mines, were considerably higher in 1916 than in 1915, as appears in the table of production by States (p. 243). The average price received for the total production was $4.56 a ton. The price paid in Missouri and Colorado was approximately $6.25 a ton, but in the other States the averages ranged from $3.50 to $5 a ton. It is understood that at the end of 1916 the price had advanced still further, but no definite information concerning the quotations is available.

NOTES ON THE BARYTES DEPOSITS OF THE UNITED STATES.

Considerable information concerning the geology of the known barytes deposits of the United States was given in the report for 1915.[1] New developments of importance are noted below.

EASTERN STATES.

ALABAMA.

In 1916 production from deposits in Alabama was reported by 4 operators, as compared with 1 operator in 1915, and the production increased from less than 500 short tons in 1915 to 7,631 short tons in 1916. In 1916 sales were reported by 4 operators whose average price was $3.56, as compared with 1 operator in 1915 who received essentially the same price.

Deposits near Jacksonville, Calhoun County; Vincent, Harper, and Wilsonville, Shelby County; and Leeds, Jefferson County, were under development, and a considerable production was made from

[1] Hill, J. M., Barytes and strontium: U. S. Geol. Survey Mineral Resources, 1915, pt. 2, pp. 166-179, 1916.

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the mine in Jefferson County, at which a steam-driven hoisting plant and log washer is operated. The mine is about 5 miles south of Leeds in the flat valley bottom east of Little Cahaba River. The Chickamauga (Pelham) limestones (Ordovician), in which the valley is cut,[1] strike north-northeast and dip southeast at steep angles. The mining has exposed the very rough surface of the underlying blue-gray limestone, in which barite in irregular masses replaces the lime and magnesium carbonates. The barytes is mined from the red residual clay overlying the limestone and some large masses of barytes have been found, though the great bulk of the barytes ranges from 1 to 4 inches in size and is of high grade.

From 1 to 3 miles north of Angle station and about 12 miles northwest of Jacksonville, Calhoun County, there are a series of barytes deposits on which a little development has been done. These deposits lie at the base of a white quartzite ridge in red residual clay that is derived from blue-gray magnesian limestone, whose age has not been definitely determined but which is probably Knox dolomite.

In the vicinity of Vincent, Harpersville, and Wilsonville, eastern Shelby County, there are small irregular masses of barytes in the red residual clays derived from limestones of Beekmantown age.[2] Shipments have been made from several small pockets, and it is reported that at a number of places indications point to larger bodies.

GEORGIA.

The marketed production of barytes from near Cartersville, Bartow County, in 1916 was 104,784 short tons, valued at $401,295. This was an increase of 73,757 short tons, or nearly 238 per cent, over the quantity of barytes sold from this district in 1915. Nine operators reported sales of barytes in 1916, as against 6 in 1915. The average price per short ton paid in 1916 was $3.83, as compared with $3.31 in 1915.

This remarkable increase is to be explained in part by the entrance of several of the lithopone makers into the mining of one of their crude materials, and in part by the greatly enlarged demand by makers of barium chemicals. Two other factors which have caused the expansion of this industry were the establishment by Thompson-Weinman & Co. of a grinding plant at Cartersville and the nearness to the great markets for lithopone and barium chemicals of the Georgia barytes as compared with that from Missouri. It seems probable that the last-mentioned factor has been of most influence in the shifting of largest State production from Missouri to Georgia.

The Cartersville deposits are of sufficient size to warrant operations on a large scale, which is not the case with some of the other deposits in the United States. Operators have been quick to recognize this and as a consequence probably the most efficient equipment for barytes mining to be seen in the country is at Cartersville. The red residual clay containing barytes is dug by steam shovel from large pits and is mechanically transported to the washing plants, which consist of log washers and jigs. It would appear that the cost of production must be low and that the recovery of barytes is corre-

[1] Butts, Charles, U. S. Geol. Survey Geol. Atlas, Birmingham folio (No. 175), 1910.
[2] Butts, Charles, U. S. Geol. Survey Geol. Atlas, Montevallo-Columbiana folio (in preparation).

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spondingly high, as compared with that of mines worked by hand in other parts of the country.

ILLINOIS.

Barytes has been known to occur in the galena-fluorspar veins of southern Illinois, and it was reported to the Geological Survey that one operator in Pope County would be in a position to supply barytes early in 1917.

KENTUCKY.

The marketed production of barytes from Kentucky deposits in 1916, was 11,068 short tons, valued at $54,995, an increase of 3,315 short tons, or nearly 43 per cent over the output in 1915. In 1916 sales were reported by 17 operators, as against 20 operators in 1915. The average price per ton received in 1916 was $4.97, as compared with $3.67 in 1915. Fayette County produced 3,829 short tons; Jessamine County, 447 short tons; Woodford County, 1,397 short tons; and the remainder came from Boyle, Clark, Garrard, and Lincoln counties. Apparently most of these deposits are worked in a small way either by the owners of the land or on a royalty basis by others, and the output is for the most part sold through Thompson-Weinman & Co.

MISSOURI.

The total marketed production of barytes in Missouri in 1916 was 58,223 short tons, valued at $365,111—an increase of 19,110 short tons, or nearly 50 per cent, over the production in 1915. In 1916 there were 77 operators who reported sales, as against 63 in 1915, and the average price per short ton in 1916 of $6.27 was an increase of $2.22 a ton over the average price of 1915. As usual, the largest output was from Washington County mines, the marketed production in 1916 being 40,626 short tons; Jefferson County mines reported sales of 2,810 short tons; and those in St. Francois County 2,136 short tons. The remainder of the output was from Benton, Cole, Franklin, Miller, Morgan, and Texas counties.

Barytes mining in Missouri is carried on chiefly by small operators, for the most part with little or no capital and by hand methods. These small operators work both on their own farms during off season and on leased ground on a royalty basis. The output of any individual is small and is sold to a local buyer, most often to a storekeeper in exchange for goods. The local buyer sells either to a larger buyer at a railroad shipping point or directly to the three big barytes companies, the J. C. Finck Mineral & Milling Co., or the Nulsen, Klein & Krausse Manufacturing Co., of St. Louis, or the Point Milling & Manufacturing Co., of Mineral Point.

Probably one of the important reasons for the shifting of largest State output away from Missouri to Georgia is the difference in character of the deposits, those of Missouri not being so well adapted for operations on a large scale. A second reason is that Missouri barytes has always been considered best suited for grinding and the three large grinding companies mentioned have the situation well in hand, though, as shown by the prices paid for barytes in Missouri during 1916, there was considerable competition among them. A third

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reason and one which to the writer seems of most importance is that the largest lithopone and barium chemical plants are located closer to the Georgia field than to the Missouri field and that freight rates therefore favor the Georgia producers.

NORTH CAROLINA.

There were 878 short tons of barytes sold by the three North Carolina operators in 1916, as compared with more than 1,000 tons sold by two operators in 1915. A considerable output of barytes was made in 1916 that did not enter the market. The average price received in this State in 1916 was $3.70 a short ton, as compared with $2.79 a ton in 1915.

All of the production marketed in 1916 was made by mines near Sandy Bottom and Stackhouse, Madison County, though the old Lawton mine near Bessemer City, Gaston County, was operated part of the year and considerable stocks of barytes were accumulated.

SOUTH CAROLINA.

The barytes deposits at Kings Creek, Cherokee County, were actively worked during 1916, but as this is the only barytes mine in the State it is not possible to give figures of output.

TENNESSEE.

The marketed production of barytes from Tennessee deposits in 1916 was 32,416 short tons, valued at $123,986, an increase of 7,342 short tons, or about 29 per cent, over the output sold in 1915. In 1916 there were 8 operators who reported sales at an average price of $3.85 a short ton, as compared with 5 operators in 1915 and an average price of $2.85 a ton.

Four operators in McMinn County, reported aggregate sales of 7,024 short tons, the remainder of the output in 1916 coming from Bradley, Cocke, Loudon, and Monroe counties. A considerable part of the barytes mined in the vicinity of Sweetwater is handled through J. F. Doherty, H. J. Moore, and the Durex Chemical Works of that city. It is reported that one of the makers of lithopone has rece tly acquired barytes land near Niota.

A number of the mines in the Tennessee district have mechanical equipment for concentrating barytes, including log washers and jigs.

VIRGINIA.

A single mine in Virginia reported sales of barytes in 1916 and the output of the State was considerably below the normal production. This condition is rather difficult to explain in view of the fact that the Virginia deposits are closer to the largest markets for crude barytes than either the Georgia or the Tennessee fields. It is reported that several of the mines in Virginia will be reopened in 1917.

WESTERN STATES.

ALASKA.

No barytes mined in Alaska during 1916 was sold. It is reported that the grinding mill to be built at Sulzer will probably be completed during 1917.

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CALIFORNIA.

The Barbour Chemical Works, of San Francisco, continues to operate the barytes-witherite deposits near El Portal, Mariposa County, and was the only operator in the State to report sales in 1916. It is reported that a deposit near Hollister, San Benito County, will be developed.

COLORADO.

Three operators reported sales of 481 short tons of barytes in 1916. The largest output was from deposits on Oak Creek, Custer County, but the deposits near Sunshine, Boulder County, were productive, and it is reported that barytes occurs in bodies of commercial size near Hartsel, Park County.

NEVADA.

The American Barium Co. made a considerable production of barytes from its mines near Blair, Esmeralda County, and it is reported that deposits near Kinkade siding, Mineral County, will be on a producing basis in 1917.

BARIUM PRODUCTS.

PRODUCTION.

As will be seen from the following table, there was an increase of 90 per cent in the domestic output of barium chemicals in 1916 over 1915, the first year in which any considerable quantity of barium chemicals was made in the United States. Ground barytes increased 27 per cent in quantity in 1916 over 1915, and lithopone increased approximately 10 per cent. The value of barium products sold in 1916 was nearly double the value of the sales in 1915.

Barium products of domestic manufacture sold, 1915–16.

Product.	1915			1916		
	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.
Barium chemicals	8,823	(a)	(a)	16,792	$1,962,520	$116.87
Ground barytes	51,557	$635,318	$12.32	65,440	964,802	14.74
Lithopone	46,494	3,760,472	80.88	51,291	5,798,927	113.06
	106,874	.....	.....	133,523	8,726,249	65.35

[a] Value not available for publication.

IMPORTS.

According to statistics collected by the Bureau of Foreign and Domestic Commerce, Department of Commerce, the imports of barium products in 1916 were valued at $459,832. As is shown by the following table, a large part of the imports was lithopone, valued at $414,592, and natural barium carbonate, valued at $18,169. Apparently barium chemicals valued at only $24,999 were imported,

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of which nearly two-thirds was blanc-fixe. In other words, the barium pigments, lithopone, and blanc-fixe, represent more than 94 per cent of all imports of barium products in 1916. The large importation of lithopone is rather remarkable in view of the rapid expansion in the American industry; it can probably be explained in part by the large demands of makers of mixed paints and rubber goods.

Value of barium products entered for consumption in the United States, 1912–1916.

	1912	1913	1914	1915	1916
Manufactured barytes [a]	$26,843	$38,155	$30,463	$10,736	$2,072
Lithopone	153,303	152,980	277,822	144,567	414,592
Barium carbonate:					
Natural	15,777	13,116	8,084	12,165	18,169
Manufactured	9,938	38,949	28,221	2,786	.....
Barium binoxide	252,320	239,000	332,709	218,776	6,590
Barium chloride	27,655	37,620	68,866	31,295	608
Blanc-fixe or artificial barium sulphate	70,327	62,785	32,619	18,501	17,810
	556,168	582,605	778,804	438,826	459,841

[a] "Manufactured barytes," as given by the Bureau of Foreign and Domestic Commerce, is believed to be the equivalent of ground and floated barytes as used by the Geological Survey.

GROUND BARYTES.

Nine companies reported sales of ground barytes in 1916 and 10 grinding plants were in operation. The sales of ground barytes were 65,440 short tons, valued at $964,802, as compared with 51,557 short tons, valued at $635,318, sold in 1915.

The largest output of ground barytes was made by the three Missouri companies listed below. The establishment of a grinding plant at Cartersville, Ga., by Thompson-Weinman & Co. should do much toward increasing the production of Georgia and Alabama mines, as it will give a ready outlet for small lots of barytes mined from various deposits. It is reported that a company is contemplating the grinding of barytes at a plant near Los Angeles, Cal., now used for other purposes. It would appear that such a step might be welcomed by the Pacific coast makers of mixed paints, who now obtain their ground barytes in the East and pay high freight rates to the coast.

The average price of ground barytes in 1916, as reported to the Geological Survey, was $14.74 a short ton, as compared with $12.32 in 1915. These prices included all grades. Prices quoted by Drugs, Oils, and Paints ranged from $13–$25 a ton for the first four months of 1916 to $25–$40 in the last eight months of the year. Off-color domestic barytes was quoted at $25–$28 a ton, domestic prime white at $30–$38 a ton, and foreign prime white at $40 a short ton.

White bleached and floated ground barytes is used in ready-mixed paints, in the rubber industry, and in making stiff heavy cardboards and papers. Off-color ground barytes is used in preparing colored mixed paints and in various chemical industries.

The following list includes all the domestic companies reporting production of ground barytes in 1916:

Barbour Chemical Works, 707 West Coast Life Building, San Francisco, Cal.
Central Pigment Co., Nicholasville, Ky.
Cherokee Chemical Co., 109 Hollingsworth Street, Baltimore, Md.
Chinn Mineral Co., Harrodsburg, Ky.

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J. C. Finck Mineral & Milling Co., 101 Barton Street, St. Louis, Mo.
Lookout Paint Manufacturing Co., Chattanooga, Tenn.
Nulsen, Klein & Krausse Manufacturing Co., Levee and Sidney Streets, St. Louis, Mo.
Point Milling & Manufacturing Co., Mineral Point, Mo.
Thompson-Weinman & Co., 100 William Street, New York, N. Y.

LITHOPONE.

Six companies in the United States made lithopone in 1916 at 10 plants, most of which are near Philadelphia and New York, though one company has its plant near Chicago. The marketed production of lithopone in 1916 was 51,291 short tons, valued at $5,798,927, as compared with 46,494 short tons, valued at $3,760,472, sold in 1915.

It is reported that several new companies are contemplating the manufacture of lithopone during 1917. It seems reasonable to assume that the market can use more lithopone of domestic manufacture than the present plant capacity can supply.

The average price reported to the Geological Survey for lithopone sold by makers during 1916 was $113.06 a short ton, as compared with $80.88 a short ton in 1915. Quotations of the trade paper, Drugs, Oils and Paints, for lithopone in wholesale lots in the open market in January, 1916, were 8½ to 10 cents a pound. In February the quotations were 10½ to 12 cents a pound, and these increased to 14½ to 15½ cents in April, which prices were maintained till August, when prices began to drop, reaching a low of 8 to 8½ cents in September. The lower September quotations were maintained to the end of the year. These prices reflect the trend of the zinc market, which, however, did not fluctuate so much.

Lithopone is used principally as a pigment in the preparation of "flat" wall paints and in the manufacture of rubber goods.[1] It finds minor uses in the preparation of enamel, calcimine, and paper.

The following list includes the domestic manufacturers of lithopone who reported production in 1916 or prospective production in 1917:

Beckton Chemical Co., 3500 Grays Ferry Road, Philadelphia, Pa.
Chemical & Pigment Co., St. Louis, Mo.
Chemical Pigments Corporation, 825 Stock Exchange Building, Philadelphia, Pa.
Chemical Products Co., 616 Majestic Building, Denver, Colo.
Grasselli Chemical Co., Cleveland, Ohio.
Charles J. Greenstreet, Boatman's Bank Building, St. Louis, Mo.
Krebs Pigment & Chemical Co., Newport, Del.
Mantua Chemical Co., 3500 Grays Ferry Road, Philadelphia, Pa.
Midland Chemical Co., 1531 Railway Exchange Building, Chicago, Ill.
New Jersey Zinc Co., 55 Wall Street, New York, N. Y.

BARIUM CHEMICALS.

The new barium chemicals industry was represented by four plants in 1915 and by 11 plants in 1916, and there are reports that several more companies will make barium chemicals in 1917. The production of the various barium salts, as shown in the following table, has grown tremendously, the total output in 1916 being an increase of 90 per cent over the output in 1915. The number of plants making the various salts in 1916 was as follows: Dioxide (binoxide), 3; carbonate, 4; chloride, 5; hydroxide, 3; nitrate, 4;

[1] Toch, Maximilian, The influence of pigments on rubber: Jour. Ind. and Eng. Chemistry, vol. 9, p. 696, 1917.

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blanc fixe, 8; but it must be understood that several of the salts are made by a number of companies. The plants making barium salts are located in California, Colorado, Illinois, Kentucky, New Jersey, New York, Pennsylvania, Tennessee, and West Virginia.

Barium chemicals of domestic manufacture sold, 1915–16.

Chemical.	1915	1916		
	Quantity (short tons).[a]	Quantity (short tons).	Value.	Average price per ton.
Barium binoxide	(b)	1,980	$1,089,923	$550.47
Barium carbonate	2,746	6,844	343,582	50.20
Barium chloride	2,106	3,643	238,480	65.46
Barium nitrate	971	446	97,881	219.46
Barium sulphate (blanc fixe)	(b)	3,337	167,404	50.17
Other barium chemicals [c]	3,000	542	25,250	46.59
	8,823	16,792	1,962,520	116.87

[a] Value of production in 1915 not available for publication.
[b] Included under "Other barium chemicals."
[c] Includes, 1915: Binoxide, hydroxide, sulphate, sulphide, and other barium chemicals not specified; 1916: Hydroxide and sulphide.

The average prices for the different salts in 1916, as reported to the Geological Survey by manufacturers, are shown in the preceding table, the average for all being $116.87 a short ton. Wholesale market prices on barium chemicals [1] are reported in cents per pound for barium chlorate, nitrate, and dioxide; in dollars per 100 pounds for barium chloride; and in dollars per ton for blanc-fixe in large lots in original 1,000-pound easks. These figures have all been recalculated to the common basis of dollars per short ton and are given in the following table:

Average wholesale market prices, per short ton, for barium chemicals, 1916.

Month.	Blanc-fixe.	Barium chlorate.	Barium nitrate.	Barium dioxide.	Barium chloride.
January	$55.00	$786.00	$340.00	$440.00	$117.50
February	70.00	1,100.00	340.00	440.00	120.00
March	70.00	1,100.00	340.00	440.00	140.00
April	70.00	1,100.00	340.00	440.00	140.00
May	80.00	1,100.00	340.00	440.00	135.00
June	120.00	1,100.00	340.00	440.00	125.00
July	120.00	1,100.00	397.70	760.00	114.00
August	120.00	1,100.00	342.30	760.00	110.00
September	120.00	1,100.00	340.00	760.00	107.40
October	120.00	1,100.00	340.00	760.00	105.00
November	120.00	1,100.00	340.00	760.00	101.60
December	110.00	1,100.00	340.00	760.00	99.90
Average for year	97.91	1,073.83	345.00	600.00	117.95

The barium chemicals have a wide variety of uses and may enter into the manufacture of other products. Barium binoxide or peroxide (BaO_2) apparently finds its principal market with the manufacturers of hydrogen peroxide, though some is believed to be used in the preparation of oxygen.

Barium hydroxide is used as a chemical agent.

[1] Oil, Paint and Drug Reporter, vols. 89, 90, 1916.

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Barium monoxide has its principal use in the preparation of the binoxide and hydroxide. It is used to some extent in the manufacture of special glasses.

Barium carbonate is used in the preparation of other barium chemicals, in rat poisons, as a water softener, in the manufacture of flat wall paints, and in the ceramic and rubber industries.

Barium chloride is used in the preparation of other barium salts, as a water softener, a chemical reagent, particularly for the purification of table salt, to some extent in the ceramic arts, and in the preparation of rat poisons.

Barium chlorate is used in pyrotechnics.

Barium nitrate is used as a chemical reagent in the preparation of "green fire" and green signal lights and in the manufacture of an explosive known as saxifragin.

Barium sulphate, usually sold under the name of blanc-fixe or permanent white, is a pigment extensively used in the paint industry, in the manufacture of highly glazed papers and of putty, and in the fabrication of rubber and of lake colors.

The following domestic companies reported to the Survey that they had made barium chemicals during 1916 or were about to begin the manufacture of one or more of the chemicals early in 1917:

American Barium Co., 57 Post Street, San Francisco, Cal.
Ault & Wiborg Co., Cincinnati, Ohio.
Barbour Chemical Works, 707 West Coast Life Building, San Francisco, Cal.
Chemical Pigments Corporation, 825 Stock Exchange Building, Philadelphia, Pa.
Chemical Products Co., 616 Majestic Building, Denver, Colo.
Chicago Copper & Chemical Co., 111 West Jackson Boulevard, Chicago, Ill.
Clinchfield Products Co., 120 Broadway, New York, N. Y.
Consolidated Chemical Products Co., Hubbell Building, Des Moines, Iowa.
Durex Chemical Co., 320 Fifth Avenue, New York, N. Y.
Grasselli Chemical Co., Cleveland, Ohio.
Harrison Bros. Co. (Inc.), 3500 Grays Ferry Road, Philadelphia, Pa.
Lamar Chemical Works, 44–56 Lewis Avenue, Jersey City, N. J.
Oakland Chemical Co., 10 Astor Place, New York, N. Y.
Port Morris Chemical Works, 141 Locust Avenue, New York, N. Y.
Rollin Chemical Co., Charleston, W. Va.
Virginia Consolidated Chemical Corporation, Bristol, Va.

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GYPSUM.[1]

By R. W. STONE.

PRODUCTION.

In 1916 for the first time the total value of the gypsum products of the United States in a single year exceeded $7,000,000. Since 1912, inclusive, the annual output has been approximately 2,500,000 tons of raw material, but in 1916 the total production was over 2,750,000 short tons.

Crude gypsum mined in the United States, 1907–1916.

	Short tons.		Short tons.
1907	1,751,748	1912	2,500,757
1908	1,721,829	1913	2,599,508
1909	2,252,785	1914	2,476,465
1910	2,379,057	1915	2,447,611
1911	2,323,970	1916	2,757,730

The total value of gypsum products in the last 10 years has increased $3,000,000, or 60 per cent.

Total value of crude and calcined gypsum, 1907–1916.

1907	$4,942,264	1912	$6,563,908
1908	4,075,824	1913	6,774,822
1909	5,906,738	1914	6,895,989
1910	6,523,029	1915	6,596,893
1911	6,462,035	1916	7,959,032

In all but three of the gypsum-producing States there was an increase in production in 1916, which shows that the improvement in the industry was general and not local. As in former years New York was the largest producer of raw gypsum, Iowa ranked second, and Michigan third. Production was made in 18 States and in Alaska. Sales are credited to Illinois, Minnesota, Washington, and Wisconsin, which are not producers of raw gypsum, because they contain mixing plants and warehouses that prepare plasters for the market.

There was an increase in quantity, in average price per ton, and in total value of gypsum sold in 1916 for land plaster, for retarder in Portland cement, and for wall plaster. There was a decrease in the quantity sold as plaster of Paris and in that sold calcined to glass factories.

The following tables summarize the gypsum industry in 1915 and 1916.

[1] The statistical data in this report were compiled by Miss L. M. Jones, statistical clerk.

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Gypsum marketed in the United States, 1915 and 1916.

State.	Number of mills reporting.	Total quantity mined (short tons).	Sold without calcining.				Sold as calcined plaster.		Total value.
			Ground for land plaster.		For Portland cement, paint, and other purposes.		Quantity (short tons).	Value.	
			Quantity (short tons).	Value.	Quantity (short tons).	Value.			
1915.									
Alaska, Arizona, Colorado, Illinois,[a] Minnesota,[a] Montana, Nevada, New Mexico, Oregon, South Dakota, Virginia, Washington,[a] Wisconsin[a]	16	319,164	25,089	$52,596	49,025	$108,746	215,492	$1,073,957	$1,235,299
California	3	32,559	(b)	(b)	(b)	(b)	[b] 29,060	[b] 113,863	113,863
Iowa	5	495,860	12,086	11,422	59,823	48,508	335,057	1,218,198	1,278,128
Kansas	4	60,919	(c)	(c)	[c]17,332	[c]14,887	40,634	235,127	250,014
Michigan	8	389,791	(c)	(c)	[c]69,572	[c]63,236	245,484	623,073	686,309
New York	11	540,914	9,262	17,463	175,255	251,004	293,870	999,239	1,267,706
Ohio	4	259,036	4,030	6,485	5,131	6,485	217,811	759,550	772,520
Oklahoma	5	110,790	(c)	(c)	[c]17,580	[c]15,784	78,348	278,446	294,230
Texas	5	176,306	(b)	(b)	(b)	(b)	[b]148,138	[b] 519,879	519,879
Utah	3	23,445	(b)	(b)	(b)	(b)	[b] 20,541	[b] 75,835	75,835
Wyoming	5	38,827	.....	.....	.....	.....	25,749	103,110	103,110
	69	2,447,611	69,256	122,714	406,393	528,161	1,613,720	5,946,018	6,596,893
1916.									
Alaska, Arizona, Colorado, Illinois,[a] Minnesota,[a] Montana, Nevada, New Mexico, Oregon, South Dakota, Utah, Virginia, Washington,[a] Wisconsin[a]	17	394,315	40,349	85,606	69,511	136,919	238,877	1,129,775	1,352,300
California	4	32,575	(c)	(c)	[c]17,863	[c]34,431	12,385	74,630	109,061
Iowa	5	522,293	12,923	18,428	47,923	40,869	373,416	1,437,498	1,496,795
Kansas	4	78,257	(c)	(c)	[c]17,993	[c]18,644	48,442	304,141	322,785
Michigan	8	457,375	9,072	16,658	71,226	74,315	292,109	975,626	1,066,599
New York	8	579,827	7,169	18,710	188,077	273,322	311,264	1,167,555	1,459,587
Ohio	4	286,678	4,309	8,046	7,306	10,637	247,802	909,176	927,859
Oklahoma	5	161,661	(c)	(c)	[c]40,018	37,065	95,991	392,285	429,350
Texas	5	197,785	.....	.....	(b)	(b)	[b] 163,444	[b] 653,288	653,288
Wyoming	5	46,964	.....	.....	.....	.....	35,464	141,408	141,408
	65	2,757,730	81,879	167,136	465,240	623,294	1,805,814	7,168,602	7,959,032

[a] No crude gypsum produced in the State.
[b] Some crude gypsum included with calcined plaster.
[c] Some land plaster included with gypsum sold for Portland cement, etc.

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Gypsum marketed in the United States, 1912–1916.

Year.	Sold without calcining.														
	For Portland cement.			As land plaster.			For paint material.			For other purposes.			Total.		
	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.
1912	382,962	$509,400	$1.33	53,065	$107,058	$2.02	(a)	(a)	.....	5,591	$7,064	$1.26	441,608	$623,522	$1.41
1913	408,221	600,913	1.47	54,815	95,953	1.75	(a)	(a)	.....	100	200	2.00	463,136	697,066	1.51
1914	b 390,742	b 549,083	1.41	52,945	97,716	1.85	(b)	(b)	.....	.....	.....	.....	443,687	646,799	1.46
1915	b 406,393	b 528,161	1.30	69,256	122,714	1.77	(b)	(b)	.....	.....	.....	.....	475,649	650,875	1.37
1916	b 454,112	b 607,995	1.34	81,879	167,136	2.04	(b)	(b)	.....	11,128	15,299	1.37	547,119	790,430	1.44

Year.	Sold calcined.														
	As plaster of Paris, wall plaster, Keenes cement, etc.			For dental plaster.			To glass factories.			For Portland cement and other purposes.			Total.		
	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.
1912	1,678,417	$5,805,999	$3.46	c 3,190	$15,564	$4.88	24,159	$52,741	$2.18	25,908	$66,082	$2.55	1,731,674	$5,940,386	$3.43
1913	1,680,157	5,858,785	3.49	861	4,168	4.84	10,942	21,797	1.99	81,899	193,006	2.36	1,773,849	6,077,756	3.43
1914	1,565,937	6,038,777	3.86	641	3,374	5.26	(d)	(d)	.....	d 89,488	207,039	2.31	1,656,066	6,249,190	3.77
1915	1,520,308	5,776,826	3.80	534	2,376	4.45	11,861	26,620	2.25	81,017	140,196	1.73	1,613,720	5,946,018	3.68
1916	1,677,081	6,884,960	4.11	661	8,766	13.26	11,537	28,839	2.50	116,535	246,037	2.11	1,805,814	7,168,602	3.97

a Included under "For other purposes."
b Small quantity of paint material included with gypsum sold for Portland cement.
c Includes some casting plaster.
d Included under "For Portland cement and other purposes."

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As might be expected from the general tendency of the times, the average price per ton for gypsum and most gypsum products shows a large increase over the price in 1915. The increase is least for crude gypsum sold to Portland cement mills and greatest for dental plaster. Dental plaster is reported as produced in six States and at prices ranging from $6 to $23.50 per ton, with an average price of $13.26 per ton. In former years it has ranged from $3 to $15, with an average price of about $5. This greatly increased average price in 1916 is due to the fact that the higher priced material largely predominated in the output.

The increased average price per ton of all calcined plaster in 1916 due to higher wages and cost of all supplies will doubtless be greatly exceeded in 1917.

IMPORTS.

Gypsum imported into the United States comes almost wholly from Nova Scotia and New Brunswick and enters the ports of the New England and North Atlantic States. The proportionate value of imports to domestic production is very small and decreasing. It was about one-seventeenth in 1915 and one twenty-second in 1916.

Gypsum imported and entered for consumption in the United States, 1912–1916. [a]

Year.	Unground.		Ground or calcined.		Value of manufactured plaster of Paris.	Total value.
	Quantity. (short tons).	Value.	Quantity. (short tons).	Value.		
1912	412,697	$430,183	3,702	$19,709	$38,589	$488,481
1913	447,383	473,594	4,542	31,277	52,051	556,922
1914	369,214	392,118	3,559	27,931	24,792	444,841
1915	336,856	356,791	5,749	22,873	10,095	389,759
1916	254,131	275,043	11,706	72,345	9,085	356,473

[a] Figures compiled from records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

PRODUCTION IN CANADA.[1]

Gypsum produced in Canada, 1915–1916.

Year.	Quantity (short tons).	Value.
1915	474,815	$854,929
1916	341,618	730,831

The gypsum sold in 1916 was classified as follows: Lump, 249,759 tons; crushed, 15,680 tons; fine ground, 6,057 tons; calcined, 70,122 tons. In 1915 the quantities of the various grades were: Lump, 346,947 tons; crushed, 48,735 tons; fine ground, 6,455 tons; and calcined, 72,678 tons.

[1] Preliminary report on the mineral production of Canada during the calendar year 1916, Canada Dept. Mines, Mines Branch.

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NEW DEVELOPMENTS.

A gypsum plant was built at Hanover, Fergus County, Mont., 7 miles west of Lewistown, by the Hanover Gypsum Co. and put into operation during the summer of 1916. Soon after beginning operation the entire property was sold to the Three Forks Portland Cement Co., which operates Montana's only cement plant, at Trident. The Hanover gypsum deposit crops out 2 miles south of South Moccasin Mountain around the top of a hill. The gypsum occurs in three or more beds, each several feet thick, is white to gray and massive, and dips at an angle of 20°. A short spur track connects the plant with the Chicago, Milwaukee & St. Paul Railway. The mill calcines by the kettle process and has been in operation continuously from the time of completion in July.

Development work was begun by the United States Gypsum Co. at Heath, 10 miles east of Lewistown, Mont., on a flat-lying bed of gypsum about 13 feet thick. The property was drilled to determine the continuity of the deposit and adits were driven which show an excellent bed of gypsum with a workable thickness of 8 or more feet, some gypsum being left in the roof and floor for protection. A branch of the Chicago, Milwaukee & St. Paul Railway passes the outcrop. A mill will be built here to take the place of operations discontinued near Great Falls.

The plant of the Dakota Plaster Co., at Blackhawk, S. Dak., was burned in the spring of 1916, but reconstruction was begun that year. The new mill was put into operation in the spring of 1917.

The plant of the United States Gypsum Co. at Rapid City, S. Dak., was burned in November, 1915, and to take its place a new plant has been built at Piedmont, S. Dak. The new mill, which was put into operation in the spring of 1917, is supplied with gypsum from a quarry and underground mine and with gypsite from a deposit close to the mill.

The small mill of the Basin Cement Plaster Co., operated by Peter Enders at Basin, Wyo., was burned in April, 1915, and rebuilt, but no finished plaster was made in the new mill during 1916. At Kane, Wyo., on Big Horn River near the mouth of Shoshone River, Seth Durfee calcined gypsum in a vertical kiln 30 feet high and 20 feet in diameter and produced stucco and building blocks.

MINE AND MILL DATA.

There were 79 active gypsum mines, quarries, and pits in the United States and Alaska, which supplied 65 domestic mills in 1916. Five mills sold ground gypsum only, 26 sold only calcined material, and 34 sold both calcined and uncalcined gypsum. Of the 65 mills, 48 used rock gypsum, 8 used gypsite, and the others used both gypsum and gypsite, except one plant which reported the use of selenite crystals.

Practically all the mills are equipped with kettles for calcining. The fuel used was coal at 40 plants, oil at 18 plants, wood at 1 plant, and coal and coke at 1 plant.

Twelve plants reported the manufacture of Keenes cement and 10 plants reported making gypsum block.

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Gypsum was calcined in 1916 at plants in the following places. The number of plants at each place where there is more than one is shown by a figure:

Arizona: Douglas.
California: Amboy, Los Angeles.
Colorado: Loveland, Portland.
Iowa: Fort Dodge (5).
Kansas: Blue Rapids (2), Medicine Lodge.
Michigan: Alabaster, Grand Rapids (5), Grandville.
Montana: Great Falls, Hanover.
Nevada: Arden, Moundhouse.
New Mexico: Acme, Oriental.
New York: Akron, Garbutt (2), Oakfield (2).
Ohio: Castalia, Gypsum (2), Port Clinton.
Oklahoma: Acme, Eldorado, Okeene, Primm, Southard.
Oregon: Gypsum.
South Dakota: Black Hawk.
Texas: Acme (2), Plasterco.
Utah: Nephi, Sigurd (2).
Virginia: North Holston, Plasterco.
Washington: Tacoma (using Alaska gypsum).
Wyoming: Kane, Laramie (2), Red Buttes.

Gypsum from Nova Scotia was calcined in 1916 at Brooklyn, New Brighton, Newburgh, and New York City in New York State, and at Chester in Pennsylvania.

The location of plants using domestic gypsum is shown on the accompanying map (Pl. I), which was prepared originally for use in a report[1] published by the Bureau of Mines.

GYPSUM CRYSTALS.

Many gypsum crystals are received by the United States Geological Survey every year with inquiry as to their identity and value. For this reason a few words concerning them are in place here.

Gypsum crystals are common in certain clay and shale deposits of the Southern and Western States, particularly in the Cretaceous and Tertiary formations from Montana to Texas. The crystals glisten in the sun and attract attention, especially where they are weathered out in quantity. Because they are transparent and split readily into thin plates they are mistaken for mica. A pure gypsum crystal is colorless and transparent. The common sizes are between half an inch and 4 inches long. Curved forms and groups of crystals in rosettes are common in some places. Gypsum crystals cleave easily into thin, shiny leaves, which are flexible but break readily and are not elastic like mica. They are easily scratched with the finger nail.

Gypsum crystals as commonly found may be said to have no value. Exceptionally large, clear, or fine crystals have some place in museums and in the collections of mineral dealers, and very clear crystals are used for certain optical purposes; but the use is so small that there is no demand or regular trade in gypsum crystals. They can be made into plaster of Paris but are not used commercially for this purpose because nowhere do the isolated crystals in clay and shale beds occur in sufficient abundance to form the basis of an industry. Furthermore the crystals are not readily pulverized, their tendency being to split into minute plates. Discoveries of accumulations of gypsum crystals therefore should not excite anticipation of profit. The gypsum industry is based on deposits of massive rock gypsum and gypsite.

[1] Stone, R. W., Gypsum products, their preparation and uses: U. S. Bur. Mines Tech. Paper 155, 1917.

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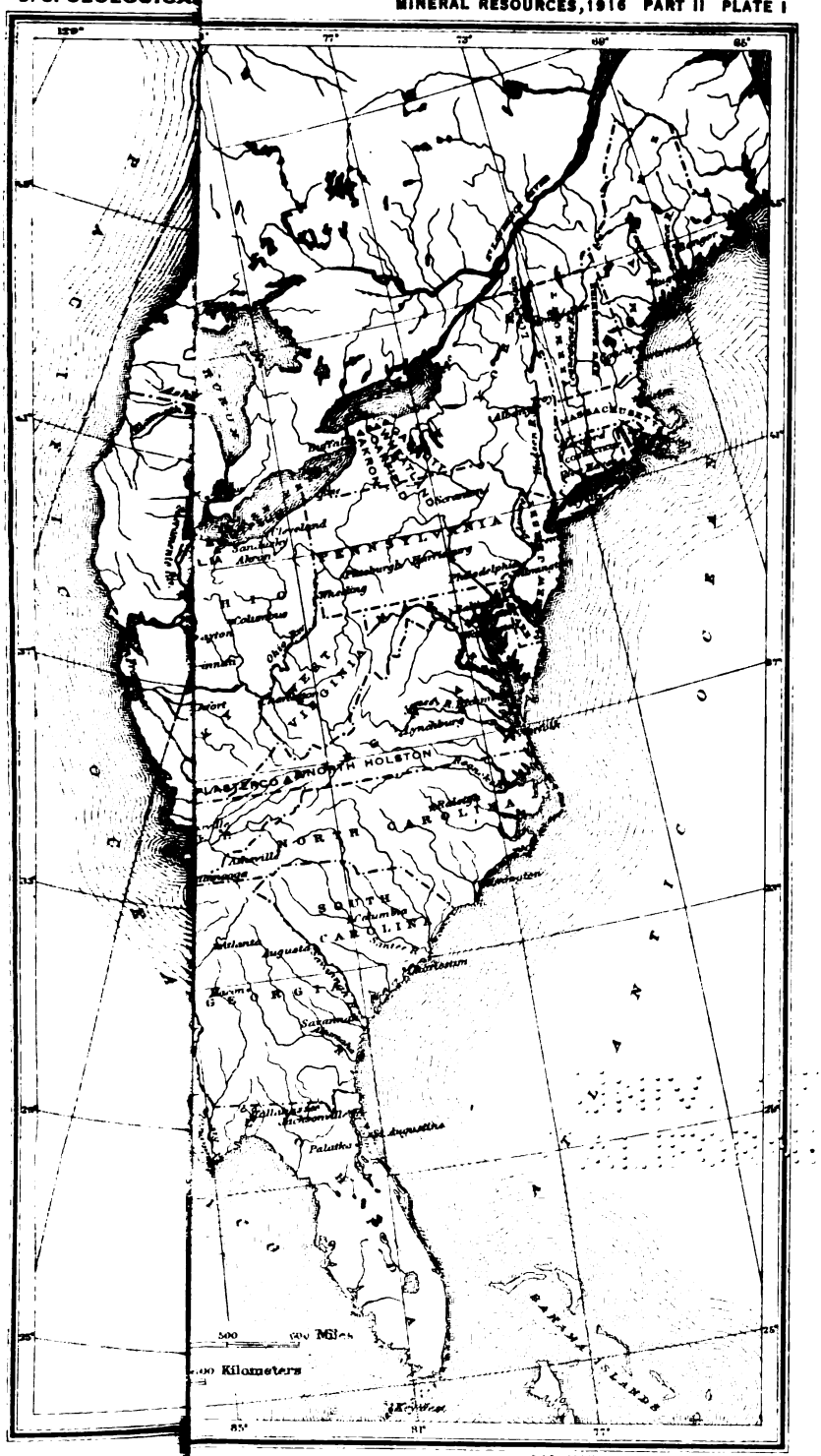

SUM

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COST OF PRODUCING AND MARKETING GYPSUM PLASTER.

Occasional letters received by the United States Geological Survey ask where machinery for the manufacture of gypsum products may be bought and imply that the inquirer contemplates entering the gypsum industry as a producer. An investigation of the market in which a new producer may reasonably expect to compete will in many places show that it is already occupied by an ample and satisfactory supply, which would mean a long uphill pull for the new product to create a demand for itself. Selling costs might equal cost of production, and the local market price would leave no margin of profit.

As shown in the table on page 257 the average value in 1916 of all plaster of Paris and wall plasters was $4.11 a ton at the mill. The proportionate cost of this plaster can be assigned approximately as follows: Mining 75 cents, milling 90 cents, shrinkage 15 cents, fuel 45 cents, repairs and supplies 85 cents, overhead charges $1.

The heads under which costs are divided include several items. The charge for mining covers labor, explosives, haulage to mill, pumping water from mine, royalty, and equivalent items. Milling includes labor and power for crushing, drying, grinding, calcining, and sacking. Shrinkage covers the decrease in weight caused by loss of water driven off in drying and calcining, by loss of dust floating off with steam from the kettles, and by loss from conveyors in the mill. Fuel includes only the cost of that used in drying and calcining, as fuel used for power is figured in milling costs. Under repairs and supplies are charged lubricant, retarder, fiber, sacks, necessary alterations to machines and buildings, and other items. Overhead charges, which are from 25 to 30 per cent of the whole cost, include administration and selling. For the first few years or until its reputation is established and a demand is created for its products, a new company may have selling costs ranging from 50 to 100 per cent of the cost of production.

The cost of producing plaster varies in different localities and at the same mill in different months, because of differences in labor conditions, in quantity produced, fluctuations in demand, and other vital factors. There is always a low production during the winter months because of a general decrease in building operations.

The cost of building and equipping a plaster mill of a given capacity will vary considerably, dependent on several factors, among which are availability and kind of material, labor conditions, and type of mill. When, as in 1917, the cost of all supplies, machinery, and labor is high, a completely equipped mill of wooden construction with a capacity of 25 tons a day, with necessary mine development and office, will probably cost not less than $15,000.

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ASPHALT.

By JOHN D. NORTHROP.

INTRODUCTION.

In the industrial world the term asphalt is commonly used to denote all types of solid and semisolid bitumen or mineral pitch, irrespective of composition or origin, that are employed in the arts and industries. Although used in this chapter in its industrial sense, the term asphalt is so qualified as to indicate broadly the source of the materials referred to. Thus "natural asphalt" is used to denote all forms of asphaltic material found in nature; it includes the native bitumens, maltha, grahamite, and gilsonite; the so-called "pyrobitumen," wurtzilite (elaterite); the asphalt-impregnated rocks, sandstone, limestone, and shale; and the cerous hydrocarbon, ozokerite. The term "manufactured asphalt," as used in this chapter, includes, on the other hand, a variety of asphaltic materials ranging from viscous fluids to tenacious solids and obtained as by-products or residuals in the process of refining asphaltic or semiasphaltic petroleum.

OCCURRENCE AND DISTRIBUTION.

The natural asphalts occur in the United States in three principal forms: (1) as viscous, semiliquid substances filling interstices and cavities in rock of almost every type, but found most abundantly in sand, sandstone, and limestone; (2) as viscous and semisolid tenacious exudations from the earth, either directly from exposed bituminous rocks or from subterranean passages; (3) as solids in the form of veins or irregular bodies, cutting across or lying between layers or masses of rocks. Stratigraphically, the natural asphalts here considered occur in commercial quantities in or associated with sedimentary rocks of all ages from Ordovician to Pleistocene.

The distribution of the natural asphalts in the United States is wide, deposits having been found at numerous localities in fully a dozen States, though commercial production is now limited to only a few localities in California, Colorado, Kentucky, Texas, Oklahoma, and Utah.

The manufactured asphalt produced in the United States is obtained from certain grades of crude petroleum found in California, Texas, Louisiana, Oklahoma, Kansas, and Illinois, as well as from the heavier grades of Mexican crude, which are imported in ever increasing quantities for the manufacture of asphalt and asphalt products.

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USES.

The uses of the asphaltic materials produced in the United States are many and varied. Bituminous sandstones and limestones are utilized for paving. Gilsonite is widely utilized in the manufacture of paints, varnishes, japans, insulations, and rubber substitutes, and enters into the manufacture of paving cements. Grahamite is utilized chiefly in the manufacture of ready roofing; mastic made with it is more resistant to grease and oil than the ordinary type; it has been made a constituent of varnishes, of rubber substitutes, and of filler for brick and artificial stone blocks, and when softened with heavy asphaltic flux grahamite is even more rubbery and elastic than gilsonite under the same conditions and is less susceptible to heat. Wurtzilite, known to the trade as elaterite, is utilized principally in the manufacture of marine and iron paints, acid-resisting compounds and other protective coatings, and as a substitute for rubber in certain compounds. Ozokerite, or natural paraffin, is utilized in the manufacture of shoe and leather polish, sealing wax, candles, and pomades, and for electrical insulation.

The more fluid varieties of manufactured asphalt are utilized as dust palliatives and semipermanent road binders for the surface treatment of roads, and as fluxes for softening solid native bitumens and residuums in the preparation of paving cements. The more viscous and semisolid varieties are made with the appropriate consistency to be utilized directly for paving and road surfacing. They are also utilized widely in the manufacture of roofing felts and building papers, and as a binder for briquetting coal.

GENERAL CONDITIONS.

The year 1916 was one of prosperity for the asphalt industry in the United States. The quantity of natural asphalt produced and sold at mines and quarries in that year exceeded the quantity marketed in any preceding year except 1909 and 1910, and the value of the output exceeded that in any preceding year except 1907. The combined production in the United States of manufactured asphalt derived from domestic and from Mexican petroleum was 20 per cent greater than in any preceding year. All branches of the industry shared in the general prosperity, and gains in output included, except for grahamite, each of the principal varieties of asphaltic material produced in the country.

Ozokerite from domestic sources reappeared in the statistics of production for the first time since 1907.

The prosperity in the asphalt industry in 1916 was a consequence of the general prosperity of the entire country that expressed itself through the automobile industry in a decided movement toward better roads and cleaner, quieter, and more sanitary pavements. The demand for asphaltic substances and high-grade bitumens in industries other than paving is steadily increasing as new uses for materials of this type are developed, and the outlook for still greater expansion in all branches of the industry is bright. Prices for all forms of natural and manufactured asphalt averaged appreciably higher in 1916 than in other recent years, the gains in prices of the manufac-

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tured varieties, due largely to increased costs of manufacture, being sufficient in certain localities, notably California and Texas, to stimulate the production of competing natural materials.

Imports of high-grade paving asphalt, mainly from the island of Trinidad and from Venezuela, continued to exceed in quantity the combined output of all varieties of natural asphaltic materials from domestic sources.

Substantial progress was made in 1916 in the development of the industry, referred to in the chapter on asphalt in 1915,[1] designed to utilize the rich bitumen-impregnated shales of western Colorado for the manufacture of heat-resisting, acid-proof substitutes for hard or vulcanized rubber. The establishment of this industry on a permanent basis in 1917 appears to be certain.

MARKETED PRODUCTION.

NATURAL ASPHALT.

The quantity of natural asphalt, including bituminous rock, grahamite, gilsonite, wurtzilite, and the native paraffin, ozokerite, produced and sold at mines and quarries in the United States in 1916 was 98,477 short tons. This quantity was greater by 22,726 tons, or 30 per cent, than the output in 1915, and was less by only 584 tons, or about 0.6 per cent, than the record output of 99,061 tons in 1909.

The average price received for this material at the sources of production was $9.37 a ton, and the gross market value was $923,281, a gain of $2.42 in average price per ton and of $396,791, or 75 per cent, in gross market value, compared with 1915.

An analysis of the statistics of production in 1915 and 1916 shows gains in 1916 of 42.5 per cent in the output of bituminous rock and of 31 per cent in the combined output of gilsonite and wurtzilite, but a loss of 22 per cent in the output of grahamite. With regard to the market value of these products, the statistics for 1916 show gains of 26 per cent for bituminous rock and of 129 per cent for gilsonite and wurtzilite combined, but a loss of a little less than 2 per cent for grahamite.

The large gain in market value of gilsonite is chiefly due to the inability of the producers of this mineral to supply the demand for it, an inability resulting solely from the lack of railway facilities in proximity to the mines. The moderate decline in the production of grahamite in 1916 is believed to be accounted for by the increased use of manufactured asphalt in the preparation of ready roofing, for which practically all the grahamite produced in the country is used.

Fifteen companies and individuals were engaged in quarrying or mining natural asphaltic material in the United States in 1916, as compared with 14 in 1915.

[1] U. S. Geol. Survey Mineral Resources, 1915, pt. 2, p. 137, 1917.

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The following table shows the combined output of all forms of natural asphalt entering the markets from mines and quarries in the United States since 1882:

Natural asphalt, bituminous rock, and ozokerite sold at mines, 1882–1916.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1882	3,000	$10,500	1894	60,570	$353,400	1906	73,062	$674,934
1883	3,000	10,500	1895	68,163	348,281	1907	85,913	928,381
1884	3,000	10,500	1896	80,503	577,563	1908	78,565	517,485
1885	3,000	10,500	1897	75,945	664,632	1909	99,061	572,846
1886	3,500	14,000	1898	76,337	675,649	1910	98,893	854,234
1887	4,000	16,000	1899	75,085	553,904	1911	87,074	817,250
1888	50,472	190,500	1900	54,389	415,958	1912	95,166	865,225
1889	51,760	174,037	1901	63,134	555,335	1913	92,604	750,713
1890	41,016	216,666	1902	84,632	461,799	1914	79,888	642,123
1891	45,079	249,264	1903	55,068	483,282	1915	75,751	526,490
1892	87,710	453,375	1904	64,167	420,701	1916	98,477	923,281
1893	47,779	372,232	1905	62,898	305,242			

MANUFACTURED ASPHALT.

Domestic.—The sales in 1916 of manufactured asphalt derived from crude petroleum of domestic origin, as reported to the Geological Survey, amounted at the sources of production to 688,334 short tons. Compared with the production marketed in 1915, this quantity is greater by 23,831 tons, or 3.6 per cent.

The average price received for the material sold in 1916 was $8.98 a ton, a gain of $1.88 a ton over the average price received in 1915. This gain was sufficient to make the total market value of the production in 1916, amounting to $6,178,851, exceed the value of the output in 1915 by more than a million dollars.

Manufactured asphalt includes asphaltic oils used either for road sprinkling to allay dust or as a flux for softening harder bitumens and also semisolid products and residual pitches used in paving or in the roofing trade. The quantity of road oil and flux obtained from domestic petroleum and sold in 1916 was 404,009 short tons, market value $3,158,603, an average of $7.82 a ton. Compared with 1915 this output shows loss of 13,800 short tons in quantity but gain of $2.09 in average price per ton. The quantity of paving asphalt and residuals was 284,325 short tons, market value $3,020,248, an average of $10.62 a ton. Compared with 1915 this output shows gain of 37,681 tons in quantity and of $1.20 a ton in average price.

Mexican.—The sales in 1916 of manufactured asphalt derived from Mexican crude petroleum amounted to 572,387 short tons, the total market value being $6,018,851, an average price of $10.52 a ton. Compared with 1915 these data show gains of 184,069 tons, or 47 per cent, in quantity, of 91 cents in average price received per ton, and of $2,288,415, or 61 per cent, in total market value of the output.

The quantity marketed in 1916 includes 295,682 tons of road oil and flux, valued at $2,486,938, an average price of $8.41 a ton; also 276,705 tons of paving asphalt and residual pitch, valued at $3,531,913, an average price of $12.76 a ton. Gains over corresponding factors in 1915 amounted to 69 per cent in quantity and 83 cents in average price per ton for road oil and flux and to 30 per

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cent in quantity and 49 cents in average price per ton for paving asphalt.

The number of plants supplying the output of manufactured asphalt in the United States in 1916 was 37, of which 25 used exclusively petroleum of domestic origin, 9 used exclusively petroleum of Mexican origin, and 3 used petroleum from both sources.

An indication of the extent to which manufactured asphalt has invaded the market for natural varieties in the paving industry of this country is afforded by the fact that the gross sales of heavy asphalts and residual pitches derived from domestic and from Mexican petroleum and used in paving amounted in 1916 to 561,030 short tons, whereas gross sales for all purposes of all natural asphalts from domestic sources plus imports of natural asphalt and bituminous rock amounted to only 246,190 short tons in that period. Increased costs of manufacture, higher freight rates between Mexico and the United States, and the levy by the Mexican de facto Government of higher export taxes on petroleum will undoubtedly result in further increases in prices for all grades of manufactured asphalt in 1917 and may induce a wider utilization of domestic petroleums for this purpose. Requirements for fuel purposes of domestic petroleums, suitable also for the manufacture of asphalt, have, however, resulted in increased prices that will tend to offset any decided increase in their use for the manufacture of asphalt.

The succeeding tables show by years and by sources of crude petroleum utilized the quantity and market value of the manufactured asphalt made and sold in the United States since this phase of the asphalt industry became important.

Manufactured asphalt from domestic petroleum sold at refineries, 1902–1916.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1902	20,826	$303,249	1907	137,948	$1,898,108	1912	354,344	$3,755,506
1903	46,187	522,164	1908	119,817	1,540,396	1913	436,586	4,531,657
1904	44,405	459,135	1909	129,594	1,505,427	1914	360,683	3,016,969
1905	52,369	452,911	1910	161,187	2,225,833	1915	604,503	4,715,583
1906	64,997	645,406	1911	277,192	3,173,859	1916	688,334	6,178,851

Manufactured asphalt from Mexican petroleum sold at refineries, 1913–1916.

Year.	Quantity (short tons).	Value.
1913	114,437	$1,743,749
1914	313,787	4,131,153
1915	388,318	3,730,436
1916	572,387	6,018,851

PRODUCTION BY CLASSES AND BY STATES.

The following tables record by principal varieties the sales of asphaltic material at the sources of production in the United States and show the distribution by States of the output of the natural varieties during the last five years:

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Asphalt sold at mines and refineries, 1912–1916, by varieties.

Variety.	1912		1913		1914	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Bituminous rock	[a] 54,762	[a] $173,018	57,549	$173,764	51,071	$162,622
Maltha	474	3,518				
Wurtzilite (elaterite)	[b] 8,452	[b] 115,620	35,055	576,949	19,148	405,966
Gilsonite	31,478	573,069			9,669	73,535
Grahamite	(c)	(c)				
	95,166	865,225	92,604	750,713	79,888	642,123
Manufactured or oil asphalt [d]	354,344	3,755,506	436,586	4,531,657	360,683	3,016,969
	449,510	4,620,731	529,190	5,282,370	440,571	3,659,092

Variety.	1915		1916	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Bituminous rock	44,329	$157,083	63,172	$197,286
Wurtzilite (elaterite)	20,559	275,252	26,870	629,640
Gilsonite				
Grahamite	10,863	94,155	8,431	92,555
Ozokerite			4	3,800
	75,751	526,490	98,477	923,281
Manufactured or oil asphalt [d]	664,503	4,715,583	688,334	6,178,851
	740,254	5,242,073	786,811	7,102,132

[a] Includes small output of mastic.
[b] Includes grahamite.
[c] Included in wurtzilite.
[d] This item includes material derived from petroleum of domestic origin only.

Natural asphalt sold at mines, 1912–1916, by States.

State.	1912		1913		1914	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
California	36,741	$100,481	27,870	$69,825	28,186	$77,810
Kentucky	[a] 10,145	[a] 46,032	[a] 17,465	[a] 60,131	[a] 18,935	[a] 66,298
Oklahoma	15,766	85,643	16,459	91,416	9,669	73,535
Texas	(b)	(b)	(b)	(b)	(b)	(b)
Utah	32,514	633,069	30,810	529,341	23,098	424,480
	95,166	865,225	92,604	750,713	79,888	642,123

State.	1915		1916	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
California	17,794	$61,485	18,135	$45,102
Kentucky	[a] 19,311	[a] 65,352	[a] 37,777	[a] 122,984
Oklahoma	16,907	118,351	15,431	112,555
Texas	(b)	(b)	(b)	(b)
Utah	[c] 21,739	[c] 281,302	[c] 27,134	[c] 642,640
	75,751	526,490	98,477	923,281

[a] Includes Texas.
[b] Included in Kentucky.
[c] Includes Colorado.

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CONDITIONS AND PRODUCTION IN THE PRINCIPAL PRODUCING STATES.

California.—The natural asphalt mined in California in 1916, which amounted to 18,135 short tons, valued at $2.49 a ton, consisted of bituminous sandstone from the well-known localities in Santa Cruz and San Luis Obispo counties and was produced and utilized for paving and for road improvement. The moderate increase in the production of this material in 1916 is interpreted as an indication of a greater increase in 1917, predicated on the advancing prices of competing varieties of manufactured asphalt.

The output of manufactured asphalt in California was distributed in 1916 among 16 refineries and amounted to 257,930 short tons, valued at $1,958,946, an average price of $7.59 a ton. Compared with statistics for 1915, these figures show increase of 19,013 tons, or 8 per cent, in quantity, of $1.24 in average price per ton, and of $441,967, or 29 per cent, in market value.

Of the output in 1916 of manufactured asphalt in California, 108,228 short tons consisted of road oils and fluxes, valued at $633,579, an average price of $5.85 a ton, and 149,702 short tons consisted of paving asphalts, valued at $1,325,367, an average price of $8.85 a ton.

Colorado.—The contribution of Colorado to the asphalt industry in 1916 consisted of bituminous shale, quarried in Garfield County and utilized in Chicago in an experimental plant for the manufacture of rubber substitutes. Small quantities of similar shale were shipped from Colorado sources to various points for purposes of experimentation looking to the development of the widespread deposits of this material in Colorado and Utah as sources of crude petroleum or shale oil.

Illinois.—No deposits of natural asphaltic material are known in Illinois. Certain grades of crude petroleum produced in this State are, however, utilized as sources of manufactured asphalt. In 1916 four refineries utilizing Illinois oil produced and sold 155,406 short tons of manufactured asphalt, valued at the plants at $1,285,470, the greater part of which was marketed for use in oiling roads and as a flux. One additional refinery located in this State produced manufactured asphalt from petroleum obtained from Kansas and Oklahoma.

Indiana.—One petroleum refinery in Indiana contributed largely to the marketed production of manufactured asphalt derived from domestic petroleum in 1916, its supply of crude oil coming from Oklahoma and Kansas.

Kentucky.—The production of asphaltic material in Kentucky in 1916 was restricted to two properties, one in Edmonson County and one in Breckinridge County, both of which furnished bituminous sandstone for use in paving and in road improvement.

Louisiana.—No deposits of natural asphaltic material are mined in Louisiana. Three petroleum refineries in this State contributed to the country's supply of manufactured asphalt, one deriving its production from crude oil produced in Texas and the other two from petroleum imported from Mexico.

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What is reported to be a valuable deposit of asphalt is stated [1] to have been discovered recently in Lafayette Parish, about 5 miles from Lafayette. The deposit is reported to be on the surface and to cover an area of 50 or more acres. Though the existence of this deposit has been known for many years, the inhabitants of the locality believed the material to be of no value and paid no attention to it.

Maryland.—Manufactured asphalt derived from crude petroleum obtained from Mexico was produced at three refineries in Maryland in 1916.

Missouri.—One petroleum refinery in Missouri produced manufactured asphalt from crude petroleum obtained from sources in Oklahoma and Kansas in 1916.

New Jersey.—Manufactured asphalt obtained from Mexican petroleum was produced in 1916 at two refineries located in New Jersey.

New York.—One refinery in New York marketed in 1916 manufactured asphalt derived from Mexican petroleum.

Ohio.—One plant in Ohio, utilizing Mexican and Illinois petroleums, contributed to the supply of manufactured asphalt marketed in 1916.

Oklahoma.—The output in 1916 of natural asphaltic material in Oklahoma, which amounted to 15,431 short tons, valued at $112,555, consisted of grahamite from two properties in Pushmataha County and one in Atoka County and of bituminous rock from two properties in Pontotoc County. A new source of grahamite, as yet undeveloped, was discovered in July, 1916, near Jumbo, Pushmataha County. The discoverer, Mr. John D. Townsend, of Hugo, Okla., reports the grahamite to be of excellent quality and to occur in a vein that shows a surface extent of 400 feet in a northeast direction and a width of 2 inches. At a depth of 20 feet the vein is reported to be 14 inches in width. Further efforts are being made to determine the extent and commercial value of this deposit.

Crude petroleum produced in Oklahoma and Kansas was utilized at refineries in Missouri, Illinois, and Indiana as a source of manufactured asphalt.

Pennsylvania.—Manufactured asphalt obtained from crude petroleum imported from Mexico was produced in 1916 at one petroleum refinery located in Pennsylvania.

Texas.—Deposits of bituminous limestone near Cline, Uvalde County, have for many years supplied the output of natural asphaltic material credited to Texas. Asphaltic rock from this locality is becoming increasingly popular for paving and for road improvement, and the output in 1916 was nearly double that in 1915. Statistics relating to the natural asphalt industry in Texas are included with those of Kentucky in order to avoid disclosing the operations of individual companies.

The output in 1916 of manufactured asphalt derived from crude petroleum produced in Texas was 127,259 short tons, valued at $1,631,920, an average price of $12.82 a ton. Six refineries, two of which also utilize Mexican petroleum, contributed to this production, which includes 51,068 short tons, market value $589,287, of road oils and fluxes, and 76,191 short tons, market value $1,042,633, of paving asphalts and residuals. One additional refinery in this State used exclusively Mexican petroleum as a source of manufactured asphalt.

[1] Manufacturers Rec., vol. 71, No. 20, p. 64, 1917.

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Utah.—The contribution of Utah to the asphalt industry in 1916 consisted of the natural varieties gilsonite, wurtzilite, known to the trade as elaterite, and ozokerite, the combined output of which, including a small quantity of bituminous shale produced in Colorado was 27,134 tons. This quantity is greater by 5,395 tons, or nearly 25 per cent, than the combined output of asphaltic materials from this State in 1915.

The greater proportion of this output consisted of gilsonite, the production of which was greater by 27 per cent than in 1915. The average price received in 1916 for gilsonite at railroad shipping points was $22.05 a ton, compared with $13.11 a ton in 1915. Producers of this mineral report an increasing demand for it, difficult to supply because of the long wagon haul between some of the mines and the nearest railroad shipping point, and because of the unsatisfactory condition of the mountain roads it is necessary to use.

The quantity of wurtzilite marketed in 1916 was greater by 647 per cent than the quantity marketed in 1915, though the entire production represents only a small proportion of the total output of asphaltic materials in Utah in 1916. This natural product, often referred to as "mineral rubber" because of its elasticity, is utilized in the manufacture of paints, japans, and varnishes, and of waterproof, acid-proof coatings for tanks and reservoirs. It is also utilized as a filler for rubber and in the manufacture of rubber substitutes. According to Taylor [1] its uses were extended in 1916 by the successful employment of it as a primary constituent in prepared flooring. He states:

> This preparation has all the qualities of elaterite itself; that is, it is firm, tough, and has the quality of hard rubber. Its wearing qualities are better even than cement. The preparation has been used on the boardwalks at Atlantic City, its depots, and other public places.

Steps were taken in 1916 by the Rozel Asphalt Co., of Ogden, toward the development of a deposit of soft asphalt that underlies Great Salt Lake offshore from the Rozel Hills, in Box Elder County. A shaft 160 feet deep, sunk to the level of the asphalt bed, has demonstrated the presence of an enormous quantity of soft asphalt in this locality, and effort is being made to find a market for the type of material available.

The quarries of bituminous sandstone in Utah were idle throughout 1916.

The most important development in this State in 1916 was the reopening, after many years of idleness, of the ozokerite deposits in Wasatch County, in the vicinity of Soldier Summit. To the Wasatch Ozokerite Co. (now the American Chemical & Ozokerite Co.), belongs the credit for this enterprise.

According to Higgins [2] the property of this company is located on the crest of the Wasatch Range, within a few hundred yards of the railroad station of Soldier Summit, and includes 160 acres of patented land and 80 acres of unpatented claims that are believed to embrace the best of the ozokerite-bearing land in the district. The ozokerite deposits in this locality have been worked in a desultory fashion for many years, and many masses of pure wax are said to have been

[1] Taylor, A. V., Oil and hydrocarbons in Utah: Salt Lake Min. Rev., vol. 18, No. 19, p. 43, 1917.
[2] Higgins, W. C., The ozokerite deposits of Soldier Summit, Utah: Salt Lake Min. Rev., vol. 18, No. 12, p. 17, 1916.

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exposed in underground workings and subsequently lost as a consequence of caving. According to Howard [1] the principal mine in this locality—

is opened by a shaft 225 feet deep, on a zone of vertical fractures containing the ozokerite, and by drifts at 44 feet, 98 feet, and 250 feet. The ore is drilled with augers and broken by back-stoping. The ozokerite is found in veinlets in narrow fissures along the strike of the crushed strata and surrounding the brecciated shale and shaly limestones, with local swellings to as much as 3 feet. Close and careful timbering is necessary. The 44-foot level is extended to the surface and has been used as a haulage adit.

Since acquiring this property its present owners have put in a hoist in the main shaft at the mine and have erected and equipped a milling plant near-by, the first unit of which has a capacity of 1,200 pounds of refined wax a day. Active production, which began in October, 1916, resulted in the marketing of 7,600 pounds of ozokerite before the end of the year.

In order to supply the various trades that utilize ozokerite with products adapted to their particular needs the American Chemical & Ozokerite Co. has equipped a chemical plant near Chicago for the compounding of ozokerite products and the manufacture of other products derivable from the various hydrocarbon minerals of Utah. Electrotypers' wax, prepared from domestic ozokerite at this plant is already on the market and is being successfully used at a number of printing establishments throughout the country.

IMPORTS.

ASPHALT AND BITUMINOUS ROCK.

Asphalt and bituminous rock imported for consumption in the United States, 1912–1916.

Year.	Crude.		Dried or advanced.		Bituminous limestone.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1912	193,645	$726,345	20,707	$177,992	3,976	$15,808	218,328	$921,145
1913	[a] 207,033	738,452	[b] 14,750	133,336	6,395	38,823	228,178	910,611
1914	137,352	664,558	.....	.....	1,705	11,060	139,057	675,618
1915	135,276	661,356	.....	.....	2,976	19,001	138,252	680,357
1916	147,383	732,917	.....	.....	330	1,795	147,713	734,712

[a] Includes dried or advanced asphalt for last three months of 1913.
[b] Last three months of 1913 included in crude asphalt.

[1] Howard, L. O., Ozokerite in Utah: Min. and Sci. Press, vol. 112, p. 909, 1916.

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Asphaltic material imported into the United States, 1915–1916, by countries

Imported from—	1915		1916	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.
Europe:				
Germany	658	$4,854	.....	.....
Italy	492	3,438	.....	.....
Switzerland	200	1,637	295	$1,795
England	774	9,801	794	8,599
North America:				
Canada	35	708	124	1,642
Mexico	56	755	22	381
West Indies:				
Barbados	64	6,426	123	6,279
Trinidad and Tobago	92,107	498,900	92,858	494,740
Other British West Indies	.....	.....	520	23,470
Cuba	391	9,243	524	12,701
South America:				
Venezuela	28,659	144,595	36,626	185,095
Oceania:				
Philippine Islands	.....	.....	1	10
	123,436	680,357	131,887	734,712
Equivalent in short tons	138,252	.....	147,713	.....

The foregoing tables show that the greater part of the asphaltic material obtained by consumers in the United States from foreign sources consists of crude asphalt from Trinidad and Venezuela, imports of asphaltic materials from other countries being relatively small. Increased receipts of Trinidad and Bermudez (Venezuela) asphalts in 1916, as compared with 1915, reflect the increased demand in the United States for all types of material used in the paving and allied industries.

In addition to the imports of asphalt and bituminous rock in 1916, asphalt products aggregating $17,768 in declared value were imported for consumption during the year.

OZOKERITE.

The following table shows the receipts from foreign sources of mineral wax, including ozokerite, ceresine, and various compounded products of which these waxes form the base, entered for consumption in the United States during the last five years:

Mineral wax imported for consumption in the United States, 1912–1916.

Year.	Quantity (pounds).	Declared value.	
		Total.	Price per pound.
1912	6,352,003	$488,894	$0.077
1913	7,141,514	549,992	.077
1914	8,191,529	498,695	.061
1915	2,795,256	210,019	.075
1916	3,007,676	196,185	.065

Wholesale prices of imported ozokerite in the New York market ranged in 1916 from 45 to 60 cents a pound for the crude brown varieties and from 80 to 90 cents a pound for the green. Competing

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American ozokerite which appeared in New York market quotations in September held steadily at 35 cents a pound throughout the remainder of the year.

ICHTHYOL.

The following table compiled from the records of the Bureau of Foreign and Domestic Commerce shows the quantity of ichthyol, a peculiar form of asphaltic material employed as an antiseptic and medicament, and ichthyol substitutes imported for consumption in the United States during the last five years:

Ichthyol and ichthyol substitutes imported for consumption, 1912–1916.

Year.	Quantity (pounds).	Value.
1912	51,502	$69,670
1913	58,485	83,034
1914	61,416	86,415
1915	24,921	28,560
1916	116,738	93,762

Wholesale prices of true ichthyol ranged in the New York market from $12 to $18 a pound during 1916. Trading in this product was light because of the scarcity of this material, which is produced only in Austria and which has been increasingly difficult to obtain since the beginning of the war. Although a small proportion of the imports in 1916 consisted of true ichthyol, the bulk of the receipts from foreign sources of material classed by the Customs Service as ichthyol consisted of ichthyol substitutes obtained from Switzerland and from Japan. Swiss substitutes were quoted in the New York wholesale market at $3 a pound.

The scarcity of true ichthyol in the United States has resulted in considerable research work, seeking to extract ichthyol oil from domestic bituminous material of various types. As there are in this country no known deposits of asphaltic material identical with those from which ichthyol is derived, the difficulty of duplicating the foreign product is greatly increased. Favorably recommended substitutes for ichthyol prepared from domestic materials are, however, available in the markets.

EXPORTS.

The foreign trade of the United States in unmanufactured asphalt decreased slightly in quantity but increased materially in value in 1916 as compared with 1915. The value of asphalt products exported was considerably greater in 1916 than in 1915. Significant increases were made in 1916 in shipments of unmanufactured asphalt to Sweden, Uruguay, Panama, and of asphalt products to France, Panama, Cuba, Uruguay, British India, Hongkong, Japan, Australia, and New Zealand.

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The following tables have been compiled from the records of the Bureau of Foreign and Domestic Commerce:

Asphalt exported from the United States, 1912–1916.

Year.	Unmanufactured.		Manufactures of (value).	Total value.
	Quantity (long tons).	Value.		
1912	39,915	$886,678	$467,959	$1,354,637
1913	58,550	1,267,625	411,786	1,679,411
1914	37,246	845,838	401,182	1,247,020
1915	38,203	735,952	438,685	1,174,637
1916	36,443	759,769	494,895	1,254,664

Asphalt exported from the United States, 1915–16, by countries.

Exported to—	1915			1916		
	Unmanufactured.		Manufactures (value).	Unmanufactured.		Manufactures (value).
	Quantity (long tons).	Value.		Quantity (long tons).	Value.	
Europe:						
Denmark	63	$2,533	$287	80	$1,142	.....
France	340	9,915	5,678	510	20,159	$20,350
Italy	.....	.....	4,058	115	5,373	6,236
Netherlands	3	93	93	17	516	7
Norway	3	80	.....	79	2,558	.....
Russia in Europe	50	3,956	.....	.....	.....	2,000
Spain	125	2,787	10,263	192	4,144	4,330
Sweden	.....	.....	1,444	2,774	52,657	.....
Switzerland	.....	.....	136	68	1,449	1,043
England	8,782	203,160	66,920	3,427	90,190	63,000
Scotland	451	9,964	1,885	199	4,291	1,244
Ireland	98	5,214	4,315	.....	.....	848
North America:						
Bermuda	.....	.....	3	.....	.....	.....
Canada	25,868	438,696	188,634	24,643	427,305	197,731
Central American States—						
Costa Rica	.....	.....	.....	.....	.....	17
Guatemala	.....	.....	79	.....	.....	7
Honduras	.....	.....	196	.....	.....	60
Nicaragua	.....	.....	20	1	24	30
Panama	9	216	10,085	690	20,575	39,977
Salvador	.....	.....	.....	.....	.....	244
Mexico	35	800	4,024	13	232	890
Newfoundland	.....	.....	.....	.....	.....	158
West Indies:						
Cuba	1,445	32,280	3,652	718	18,514	15,669
Dominican Republic	11	293	120	.....	.....	197
British:						
Jamaica	.....	.....	40	10	303	2
Other British Indies	.....	.....	14	.....	.....	13
South America:						
Argentina	556	12,868	18,453	613	21,501	1,378
Brazil	168	7,353	33,075	134	3,753	4,984
Chile	8	280	17,172	2	58	19,387
Colombia	2	100	267	.....	2	306
British Guiana	.....	.....	42	12	251	.....
Ecuador	.....	.....	36	4	111	6
Peru	.....	.....	.....	.....	.....	328
Uruguay	5	154	961	1,399	64,211	8,270
Venezuela	.....	.....	55	6	323	207
Asia:						
China	16	454	11,532	25	750	11,607
China, territory leased to Japan	.....	.....	.....	.....	.....	200
East Indies:						
British India	.....	.....	3,714	8	308	9,482
Straits Settlements	.....	.....	1,599	.....	.....	1,170
Other British	.....	.....	1,080	.....	.....	2,100
Dutch	.....	.....	1,500	.....	.....	280
French	.....	.....	321	.....	.....	527

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Asphalt exported from the United States, 1915–16, by countries—Continued.

Exported to—	1915			1916		
	Unmanufactured.		Manufactures (value).	Unmanufactured.		Manufactures (value).
	Quantity (long tons).	Value.		Quantity (long tons).	Value.	
Asia—Continued.						
Hongkong			$4,427			$21,107
Japan			6,278	312	$7,948	13,763
Russia in Asia						37
Siam			591			280
Oceania:						
British:						
Australia	134	$3,961	10,699	369	10,731	22,496
New Zealand			7,985			11,751
French						99
German			288			27
Philippine Islands			16,464			10,836
Africa:						
British South Africa	8	200	200	23	390	200
British West Africa						14
Portuguese Africa	23	575				
	38,203	735,952	438,685	36,443	759,769	494,895
Equivalent in short tons	42,787			40,816		

CONSUMPTION.

The quantity of asphaltic material actually consumed in the United States is not susceptible of accurate determination. The sum of the quantity marketed from domestic sources and the quantity imported, less the quantity exported in a given year, provides, however, an approximation of the quantity consumed that is not without value in the absence of more specific data. On this basis the consumption of asphaltic material, including both natural and manufactured varieties, in 1916 was 1,456,634 short tons, as compared with 1,224,037 short tons in 1915, and 851,699 short tons in 1914.

The principal use of asphaltic material in the United States is in highway improvement and in paving. Data are not available as to the quantity of asphalt used in road and pavement construction, but the following statistics [1] of asphalt pavement laid in a number of typical cities in 1916 indicate the country-wide popularity of asphalt for street improvement.

[1] Engineering and Contracting, vol. 47, No. 14, 1917.

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Asphalt pavement constructed in 1916 in certain cities.

	Square yards.	Thickness of surface (inches).	Average price per square yard, including grading.
Massachusetts:			
Revere	2,791	3	$1.50
Springfield	[a] 4,459	1½	1.73
Connecticut:			
Hartford	51,743	1½	1.58
New Haven	[b] 96,868	.....	.76
Do	5,460	1½	1.84
Stamford	9,344	2	1.64
Rhode Island: Providence	28,009	1½	1.85
New York:			
Albany	40,125	2	[c] 1.77
Batavia	3,000	2	1.75
New Jersey:			
Bayonne	46,480	1½	1.80
Do	[b] 38,460	.....	1.80
Passaic	19,990	1½	[c] 1.62
Pennsylvania:			
Erie	30,284	1½	1.69
Harrisburg	10,233	2	2.00
Scranton	13,840	2	1.83
Wilkes-Barre	38,914	2	2.00
York	15,271	2	1.85
Maryland: Baltimore	398,873	1½	[c] 1.45
Ohio:			
Cincinnati	2,660	1½	2.48
Columbus	115,964	2	[c] 2.02
Conneaut	14,924	2	[c] 1.40
Elyria	9,958	2	[c] 2.00
Lima	25,106	2	1.92
Newark	18,858	1½	.84
Indiana:			
Evansville	108,486	2	1.80
Fort Wayne	45,112	1½	[c] 1.70
Goshen	24,046	1½	1.82
La Porte	42,656	1½	1.78
Logansport	44,518	1½	1.95
Illinois:			
Kankakee	17,000	1½	.....
Oak Park	2,574	1½	[c] 1.82
Michigan:			
Flint	104,000	1½	[c] 1.35
Grand Rapids	1,178	1½	[c] 1.90
Minnesota: Duluth	21,507	2	[c] 2.22
Iowa:			
Dubuque	50,000	.....	1.80
Mason City	132,006	1½	1.68
Sioux City	12,000	2	2.10
Kansas: Topeka	64,100	2	[c] 1.35
North Carolina:			
Durham	8,200	1½	[c] 1.72
Gastonia	80,000	1½	[c] 1.36
Greensboro	6,415	1½	1.62
South Carolina: Charleston	57,828	1½	1.43
Kentucky: Louisville	47,747	2	[c] 1.74
Tennessee: Chattanooga	29,100	2	.96
Mississippi: Vicksburg	26,747	2	[c] 1.75
Colorado: Denver	63,000	2	1.85
Utah: Salt Lake City	125,932	1½	[c] 1.80
California:			
Long Beach	8,297	1½	1.55
Do	6,878	1½	1.66
Los Angeles	3,983	1	.81
Do	3,350	1½	.90
Do	[d] 65,993	1½	.93
Do	33,416	1½	.95
Do	11,181	1½	.....
Do	[d] 21,861	2	1.12
Do	381,443	2	1.17
Do	14,707	2	1.26
Oakland	52,678	1½	[c] 1.50
San Diego	2,077	2	1.55
Santa Ana	12,374	1½	1.03
Santa Barbara	[e] 16,000	1½	1.40
Washington:			
Aberdeen	19,520	2	[c] 1.53
Tacoma	1,888	1½	2.59

[a] On old concrete base.
[b] On old macadam base.
[c] Does not include grading.
[d] Paint coat for binder.
[e] 1½ to 2 inches.

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ASPHALT INDUSTRY IN PRINCIPAL COUNTRIES.

PRODUCTION.

The following table shows the output of natural asphalt (all forms) in the principal producing countries, by calendar years, except as otherwise stated, from 1906 to 1916, inclusive, as far as reliable statistics are available:

Asphalt and bituminous rock produced in principal producing countries, 1906–1916.

Year.	United States.		Trinidad.[a]		Germany.		Cuba.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1906	73,062	$674,934	150,373	$832,964	129,388	$268,631	5,717	$26,605
1907	85,913	928,381	171,271	832,274	139,567	264,494	5,571	37,594
1908	78,565	517,485	143,552	403,023	98,088	188,334	6,875	31,574
1909	99,061	572,846	159,416	459,446	85,446	176,897	11,900	48,246
1910	98,893	854,234	157,120	421,419	89,491	152,565	2,320	13,685
1911	87,074	817,250	[b] 201,284	[c] 603,800	90,256	154,938	3,638	21,928
1912	95,166	865,225	[b] 212,236	[c] 742,800	105,950	200,743	17,260	87,500
1913	92,004	750,713	[b] 257,635	[c] 1,030,540	.....	.....	[b] 1,749	30,935
1914	79,888	642,123	[b] 163,076	[c] 789,450	.....	.....	[b] 969	19,491
1915	75,751	526,490	[b] 152,349	[c] 736,760	.....	.....	[b] 486	11,247
1916	98,477	923,281	[b] 146,831	[c] 698,475	.....	.....	[d] 327	7,611

Year.	France.		Italy.[e]		Spain.		Japan.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1906	216,405	$345,599	144,802	$349,926	8,587	$17,130	43	$3,572
1907	195,136	330,065	178,127	442,014	9,057	16,001	644	5,436
1908	188,616	264,188	148,433	368,306	13,635	24,084	2,650	25,564
1909	186,298	269,161	123,361	305,159	5,822	10,282	4,614	45,205
1910	187,085	277,210	179,261	452,911	7,072	18,308	526	29,004
1911	.....	.....	207,926	591,550	[f] 4,124	8,754	1,389	13,728
1912	.....	.....	200,560	581,383	5,938	13,003	3,199	32,518
1913	.....	.....	188,601	521,398	6,153	13,402	2,491	27,242
1914	.....	.....	132,114	400,164	6,355	13,847	2,211	25,836
1915	.....	.....	52,532	184,621	4,983	10,706	.....	.....

Year.	Austria-Hungary.		Russia.		Venezuela.		Mexico.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1906	10,633	$778,781	[g] 12,517	$110,294	[b] 24,783	$96,280	1,531	$17,174
1907	11,335	727,892	[g] 14,116	101,705	[b] 42,153	167,938	4,945	182,265
1908	12,239	768,162	[g] 24,961	491,302	[b] 35,324	141,912	5,811	330,903
1909	11,179	663,246	[h] 2,665	4,599	[b] 41,767	180,061	6,031	106,484
1910	9,070	702,022	[h] 27,544	176,518	[b] 35,717	[c] 151,000	3,140	39,681
1911	[h] 8,312	652,603	.....	.....	[b] 56,183	[c] 238,000	8,912	125,322
1912	[h] 11,439	664,778	.....	.....	[b] 73,780	[c] 312,000	33,611	462,230
1913	.....	.....	.....	.....	[b] 93,854	[c] 400,000	.....	.....
1914	.....	.....	.....	.....	[b] 49,941	.....	.....	.....
1915	.....	.....	.....	.....	[b] 31,949	.....	.....	.....
1916	.....	.....	.....	.....	[b] 49,176	.....	.....	.....

[a] Includes small quantity of manjak, produced in Barbados.
[b] Exports.
[c] Estimated.
[d] Exports for six months.
[e] Only about 7 per cent of the quantity given represents asphalt, the remainder being bituminous sandstone and limestone.
[f] Figures for 1911 do not include 7,165 tons of bituminous rock for which no value was reported. Figures for 1913 do not include 5,112 tons of bituminous rock, valued at $5,833.
[g] Includes mineral pitch.
[h] Includes ozokerite.

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TRINIDAD.

The following table, presented through the courtesy of the Barber Asphalt Paving Co., shows the adverse effect of the European war on the asphalt industry of Trinidad.

Asphalt exported from Trinidad, 1912–1916, in long tons.

Year.	To United States.			To Europe.			To other countries.			Grand total.
	Lake.	Land.	Total.	Lake.	Land.	Total.	Lake.	Land.	Total.	
1912	95,111	8,600	103,711	85,299	.....	85,299	486	.....	486	189,496
1913	123,873	1,400	125,273	104,153	.....	104,153	605	.....	605	230,031
1914	67,357	2,950	70,307	75,297	.....	75,297	.....	.....	.....	145,604
1915	118,001	1,250	119,251	18,025	.....	18,025	.....	.....	.....	136,026
1916	117,719	.....	117,719	13,380	.....	13,380	.....	.....	.....	131,099

The chief source of the asphalt produced in Trinidad is a lake of pitch covering a roughly circular area of about 100 acres, situated on La Brea Point, about 30 miles south of Port of Spain. Borings in the central part and near the sides of this lake show that the bitumen fills a bowl-like depression or crater to a depth of more than 135 feet. The asphalt produced in this locality is of two principal varieties, lake pitch, obtained from the lake itself, and land pitch, the overflow in past times of pitch from the lake, and deposits of like material occurring as surface exudations in the vicinity of the lake. Containing, as it does, a larger amount of inorganic constituents than the lake pitch, the land variety is less in demand than the purer lake variety. Fresh supplies of bitumen flow constantly into the lake from subterranean sources, but the amount which thus comes in annually is less than the amount removed, as a consequence of which the elevation of the surface is being gradually lowered.

On February 22, 1917, a serious fire occurred at the refining works of the New Trinidad Lake Asphalt Co., at Brighton, Trinidad. About 60,000 barrels of refined asphalt awaiting shipment to the United States were destroyed. The refinery and cooperage plant and the cable tramway between the pitch lake and the harbor were also destroyed. Consequently exportation of both crude and refined asphalt was prevented for a time. Shipping facilities were promptly restored, however, and exportation of crude material was resumed in about two weeks from the date of the fire. A longer period was required for the restoration of the refinery and the resumption of shipments of refined material.

VENEZUELA.

As indicated by the statistics of asphalt exported from Venezuela in 1916, it is apparent that the asphalt industry in this country is in a prosperous condition.

The principal source of asphalt in Venezuela is the famous Bermudez "Pitch Lake," in the State of Sucre. It lies adjacent to Guanaco River about 30 miles in an air line from the coast of the Gulf of Paria. The so-called lake consists of an overflow of soft pitch or maltha from numerous bitumen springs and covers an area of about 900 acres to a depth of 2 to 10 feet.

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Compared with the Trinidad product Bermudez asphalt is softer, is less uniform in composition, and contains less inorganic mineral matter. It contains a higher percentage of malthenes and is consequently more susceptible to changes in temperature than the Trinidad material.

Other deposits of asphalt in Venezuela, of which there are many in the States of Sucre, Zulia, and Merida, are not actively worked, though the recent issuance by the Venezuelan Ministry of Fomento to a citizen of Maracaibo of a 25-year lease on four mining claims covering deposits of asphalt, pitch, and petroleum in the State of Merida suggests the possibility of new sources of asphalt being opened.

CUBA.

Though Cuba contains a great number of workable deposits of asphaltic material, little is being done in the matter of their commercial development. This condition of inactivity is accounted for by the geographical position of Cuba, adjacent, as it is, not only to the sources of the purest natural asphalt known, in Trinidad and Venezuela, but to the principal sources, in Mexico and in the United States, of asphaltic petroleum utilized in the production of manufactured asphalt.

The following table compiled from the records of the Pan American Union shows the trend of the asphalt industry in Cuba in the last six years:

Asphalt exported from Cuba, 1911–1916.

Year.	Quantity (long tons).	Value.	Year.	Quantity (long tons).	Value.
1911	3,248	$21,629	1914	865	$19,491
1912	15,410	86,303	1915	434	11,247
1913	1,562	30,935	1916 (six months)	291	7,611

CANADA.

Investigation of the vast resources of bituminous sand in northern Alberta, Canada, was continued in 1916 under the supervision of S. C. Ells, of the Canada Department of Mines. Detailed topographic mapping of a large part of the area in which these deposits are found has been completed. The deposits themselves are believed to be the largest of their kind in the world. A demonstration pavement, in which Alberta bituminous sand was used for the first time, was designed and constructed at Edmonton by Mr. Ells in 1915 and is still in perfect condition. As a result of his studies, Mr. Ells considers that the commercial development of the Alberta deposits will depend on the perfection of a successful process for the separation of the bitumen from the crude bituminous sand. Recently, as a Fellow of the Mellon Institute of Industrial Research, at Pittsburgh, Pa., Mr. Ells has been investigating possible separation methods. The question of the commercial recovery of crude petroleum from the sand by destructive distillation is also being considered.

A newly constructed road, the Alberta & Great Waterways Railway, is now practically completed and will furnish adequate transportation facilities to the area in which the deposits of bituminous sand occur.

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RUSSIA.

That the ozokerite industry in Russia is prospering is indicated in the following review,[1] prepared by a Russian correspondent of the Petroleum World:

On the island of Cheleken, and for that matter in the whole of the Transcaspian Province, the ozokerite industry is represented by a single firm, "Luborad," which produced 21,400 poods in 1915 and about 18,000 poods during the first ten months of 1916. Almost the whole of this output is obtained on the plot "Surinjen," Cheleken, where work is carried on by means of large shafts to a depth of 100 to 140 feet. On a small scale, ozokerite is also produced in the adjoining plot "Karakin Yomudskikh," where it is obtained by means of wells and small shafts reaching to the depth of about 40 feet.

Prospecting work has been carried on by Ivanov on plot "Bolskie Bishikhli," but difficulties in securing necessary materials and labor have temporarily stopped the digging of shafts. The Shapert Co., which worked on the same plot, and Ek, who worked plot "Malie Bishikhli," have been compelled to cease their work owing to the exhaustion of the small plots at their disposal and the consequent necessity of securing larger plots.

SWITZERLAND.

With regard to conditions in the asphalt industry in Switzerland, Consul Schulz, at Bern, Switzerland, reports[2] under date of August 11, 1916, as follows:

As Switzerland is an exporter of considerable quantities of asphalt, the introduction of the American article on any large scale seems a difficult undertaking. In normal times the exports amount to about $200,000 annually, one-fourth of which goes to Germany. Imports are valued at $50,000, chiefly from Central America and France. Most of these imports consist of a kind of tar flour, which is mixed with the product of the Swiss asphalt mines to produce certain varieties peculiar to the country.

Asphalt was sold at $6.75 a metric ton (2,204.6 pounds) before the war, while now the price has gone up to about $7.70. These prices are f. o. b. Swiss asphalt mines, of which the most important two are in this consular district. One is owned by the Neuchâtel Asphalt Co., and the other day by the Val-de-Travers Asphalt Co., both at Travers, Switzerland.

Since the beginning of the war exports have decreased, and the local demand is far below normal. Very insignificant quantities of asphalt are used for roofing purposes. Sometimes so-called bitumen, carbolineum, or tar is used. For street paving tar, delivered by the city gas works, is employed. The city of Bern has many miles of streets covered by this dust-binding material. There are but a few hundred yards of asphalt streets, and these were put down by Swiss concerns using Swiss asphalt. For the time being little or no effort is being made to extend asphalt paving in this section. A decided preference is shown for smooth-surface stone and wooden-blocked streets in the business sections, and macadamized streets and pavements in the residential section. I am informed that at Zurich the business section is largely asphalted.

The duty on asphalt and asphalt products, according to the Swiss customs tariff, is as follows per 220 pounds: Asphalt, any kind, raw, $0.0579; asphalt, in plates for floors, $0.193; asphalt, in tubes, $0.2895; asphalt cardboard, roofing felt, $0.386.

ITALY.

Conditions in Europe since the beginning of the European war have been decidedly unfavorable to the development of the asphalt industry in Italy. Exports of asphaltic limestone from the well-known Italian sources aggregated only 20,339 metric tons in 1915, as compared with 83,241 metric tons in 1914, according to the Rivista del Servizio minerario for 1915. Statistics for 1916 are not yet available.

[1] The ozokerite industry on the island of Cheleken: Petroleum World, vol. 14, No. 198, p. 136, 1917.
[2] Schulz, W. H.: Swiss asphalt trade under war conditions: Commerce Repts., Sept. 15, 1916.

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SILICA (QUARTZ).

By FRANK J. KATZ.

INTRODUCTION.

Silica (SiO_2), which has been treated in these reports under the heading "Quartz" (including flint), occurs in deposits of commercial importance in many different forms, such as vein quartz, as a constituent of pegmatites, as sand, sandstone, quartzite, or flint, as tripoli, and as diatomaceous (infusorial) earth. In some forms, such as rose, smoky, and amethystine quartz, it has value as gems. This chapter deals with silica of all kinds except gem quartz, silica used for making glass, and silica used in the form of sand, gravel, and crushed material for building, for concrete and mortar, for foundry and furnace work, and for cutting and grinding stone. Such material as is not here included is either gem material or sand, is commercially so designated, and is therefore considered in other chapters of Mineral Resources. Tripoli and diatomaceous earth are to a large extent consumed as abrasives and are considered in the chapter on abrasive materials.

USES.

Silica (quartz) as considered in this chapter is used for many purposes, principally in the manufacture of pottery, paints, and scouring soaps, as a wood filler, as a polisher, and in metallurgical and chemical processes. In the pottery industry, where it is generally called flint, silica is used in the body of the ware to diminish shrinkage and is also used in glazes. Silica for use in pottery should contain less than 0.5 per cent of iron-bearing minerals. Manufacturers of paint use considerable quantities of very finely ground silica, which forms as much as one-third of the total pigment in some paints. For this purpose finely ground crystalline material is superior to fine sand in its natural state because of the angularity of the grains, which makes them adhere more firmly to the article painted and after wear affords a good surface for repainting. The same angularity makes artificially comminuted crystalline quartz superior to natural sand for use in wood fillers. For soaps and polishing powders ground material is preferred to natural sand on account of its whiteness and angularity. For all these purposes large quantities of pure quartz sand and sandstone are finely ground and yield a product fully equal to that obtained by grinding massive crystalline quartz.

Quartz crushed and graded to various sizes is used in making sandpaper and sand belts, as a scouring agent, for "frosting" glass with sand-blast apparatus, and for other purposes. Blocks of mas-

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sive quartz and quartzite are used in the chemical industry as a filler for acid towers and as a flux in copper smelting. Ground quartz is also used in filters and in tooth powders and by dentists as a detergent.

Sand and crystalline quartz have been used in making silicon and alloys of silicon with iron, copper, and other metals in the electric furnace. Quartz may be fused in the electric furnace to make chemical apparatus, such as tubes, crucibles, and dishes.

The material known commercially in the United States as tripoli, which is the siliceous residue of decomposed limestones, also yields an excellent grade of pulverized silica, which is used for the same purpose as silica powder obtained from massive crystalline quartz and from sands and sandstones. Diatomaceous (infusorial) earth is also used to make polishing powder that is employed for similar uses to those for which quartz, sand, and tripoli powders are employed, but diatomaceous earth has somewhat different properties and most of it finds different application.

PRODUCTION.

The reports to the United States Geological Survey on the production in 1916 of various forms of silica for the uses considered in this chapter are summarized in the following table. The combined output of these materials in 1916 increased less than 1 per cent in quantity and about 18 per cent in value as compared with 1915.

Silica sold for pottery, paints, fillers, polishers, abrasives, and other uses in 1914, 1915, and 1916.

Material.	1914		1915		1916	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Quartz (vein quartz, pegmatite, and quartzite)	153,401	$360,502	112,575	$273,553	88,514	$242,786
Sand and sandstone [a]	.....	.....	95,461	386,261	110,603	489,863
Tripoli	17,218	142,428	30,711	[b] 128,957	43,257	215,216
Diatomaceous earth [c]	11,012	109,899	4,593	38,517	2,721	26,337
	181,731	612,829	243,340	827,288	245,095	974,202

[a] Includes only finely ground material. Figures probably incomplete.
[b] Value for 1915 revised in 1916.
[c] Excludes California product used for filters and as insulating and fireproofing material.

QUARTZ.

PRODUCTION.

Quartz from quartz veins, pegmatite, and quartzite amounting to 88,514 short tons, valued at $242,786, was sold in 1916. This was a decrease of 21 per cent in quantity and 11 per cent in value as compared with 1915. The decrease was for both crude and ground material but greater for the former.

The prices of crude quartz in 1916 ranged from about $1 to $4.50 and (exclusive of large quantities used in copper smelting, valued at 50 cents to $2 a ton) averaged $2.37 as compared with $3.30 in 1915 and $2.44 in 1914. Prices of ground quartz ranged from $6 to $18 and averaged $9.09, as compared with $10.56 in 1915 and $9.09 in 1914.

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Vein and pegmatite quartz and quartzite sold in the United States, 1915–16, by States.

State.	Crude.		Ground.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1915						
Arizona, Michigan, and Wisconsin	4,280	$3,739	6,673	$55,388	10,953	$59,127
California	2,898	10,600	722	9,002	3,620	19,602
Connecticut, New York, Maine, and Massachusetts	2,140	6,895	4,437	86,430	6,577	93,325
Maryland	3,025	12,718	3,182	24,139	6,207	36,857
Pennsylvania, North Carolina, and Tennessee	81,956	46,678	3,262	17,964	85,218	64,642
	94,299	80,630	18,276	192,923	112,575	273,553
1916						
Arizona, Colorado, and Washington	2,639	6,808	.....	.....	2,639	6,808
California	5,648	11,533	.....	.....	5,648	11,533
Connecticut, Massachusetts, New York, and Pennsylvania	3,044	12,507	7,262	84,758	10,306	97,265
Maryland	4,482	13,428	2,721	18,284	7,203	31,712
Michigan, Wisconsin, and Virginia	.....	.....	8,114	61,461	8,114	61,461
North Carolina, Tennessee, and Virginia	54,604	34,007	.....	.....	54,604	34,007
	70,417	78,283	18,097	164,503	88,514	242,786

Quartz sold in the United States, 1910–1916.

Year.	Crude.		Ground.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1910	49,886	$80,984	13,691	$112,773	63,577	$193,757
1911	77,759	70,430	10,184	84,692	87,943	155,122
1912	82,205	67,256	15,669	124,429	97,874	191,685
1913	74,176	54,442	23,726	147,046	97,902	201,488
1914	123,508	88,820	29,893	271,682	153,401	360,502
1915	94,299	80,630	18,276	192,923	112,575	273,553
1916	70,417	78,283	18,097	164,503	88,514	242,786

Quartz or silica for the uses here considered was produced in Arizona, California, Colorado, Connecticut, Maryland, Massachusetts, Michigan, New York, North Carolina, Pennsylvania, Tennessee, Virginia, Washington, and Wisconsin; and quartz sand and sandstone in Illinois, Ohio, Pennsylvania, and West Virginia.

QUARTZ INDUSTRY BY STATES.

Alabama.—A new firm which began operations near Trussville, Jefferson County, late in 1915 was not active in 1916.

Arizona.—Only one firm reported production in Arizona in 1916. The material was quartzite used for bottoms of reveberatory furnaces, and the production was smaller than in preceding years.

California.—Quartz was produced by at least 7 operators in California in 1916. The sources were vein quartz near Perris, Riverside County; quartz boulders at Dutch Flat, Placer County; vein quartz near Los Angeles; and vein or pegmatite quartz at Orosi, Tulare County, and in Kern, Eldorado, and Amador counties. The sales

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amounted to 5,648 short tons of crude mineral, valued at $11,533. Prices for crude quartz were $2 to $5 per ton. The quartz was used for pottery, enamel, abrasives, soap, filters, paint, facing concrete ("artificial stone"), silica brick, metallurgical flux, and in foundry work. California also produces considerable diatomaceous earth.

Colorado.—Small quantities of silica obtained near Wray, Yuma County, and Pueblo, Pueblo County, Colo., were sold in 1916.

Connecticut.—Quartz from Roxbury, Litchfield County, Conn., was ground and sold in the Bridgeport Wood Finishing Co.'s mill at Still River. The material was derived from quartz veins and was used in making soap, pottery, paint, and wood filler. Connecticut also produces silica in the form of diatomaceous earth.

Illinois.—Illinois produces a large quantity of sand and sandstone, of which 32,149 short tons, valued at $110,194, were ground in 1916 and were sold for use in pottery, paint, soap, and in the foundry. Two companies reported grinding in Ogle and La Salle counties. Illinois also contributes largely to the silica supplies of the country from the tripoli deposits in Alexander and Union counties.

Maine.—Maine produced no quartz in 1916.

Maryland.—In Maryland five firms, three of which are grinders, reported production in 1916 amounting to 7,203 short tons, valued at $31,712. The material was obtained from veins and pegmatites in Carroll, Harford, Howard, and Montgomery counties. Crude quartz sold at $3 to $5 and crushed and ground quartz at $6 and $12.50 per ton. Maryland produces diatomaceous earth also.

Massachusetts.—In Cheshire, Berkshire County, Mass., large quantities of quartzite are quarried. Most of this is used as "glass sand" and is reported in the chapter of this volume on that subject. One company marketed some quartz for use as an abrasive.

Michigan.—In Michigan there was one producer in 1916, as in previous years, with mine and mill at Ishpeming, Marquette County, and another mill at Milwaukee, Wis. The product of this mill is derived from vein quartz and is used chiefly in making paint and wood filler but also as a polisher.

New York.—One quartz quarry at Bedford, Westchester County, N. Y., was operated in New York in 1916. The product was ground in Connecticut and used in making pottery, paint, wood filler, and soap.

North Carolina.—As usual in North Carolina, there was in 1916 a single producer of quartz, who quarried quartzite at Mount Holly, in Gaston County. The output was used for packing acid towers.

Ohio.—No production of quartz was reported from Ohio in 1916, but large quantities were ground in the State and sold to local potteries and other manufactories.

Pennsylvania.—In 1916 quartz was marketed by two producers in Pennsylvania, one in Adams County, operating a quartz-grinding mill, and one in Chester County. Quartz sand and sandstones used for other purposes than those here considered are mined and milled in the State and much of the product here considered as originating in other States was ground in Pennsylvania.

Tennessee.—In 1916 Tennessee produced more quartz than all the other States combined, but the material was of comparatively low grade and of small value. The Tennessee Copper Co. reported a large output of quartz quarried from quartzite and used as flux in copper smelting.

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Virginia.—Material (said to be vein quartz) obtained at Mendota, Washington County, Va., in 1916 was ground in Bristol, Tenn., for use in polishing and cleansing compounds. The rest of the output from Virginia was crude.

West Virginia.—One producer at Berkeley Springs and one at Hancock, Morgan County, W. Va., ground sand for the purposes here considered.

Washington.—The Spokane Silica Co. quarried quartz from a large vein near Spokane and made its first sales in 1916.

Wisconsin.—One firm operating in Flieth, Marathon County, Wis., produced quartz in 1916. The product is derived from a very pure quartzite and is used for filter beds, for roofing, for concrete work, for chicken grits, and for sandpaper.

FLINT OR CHERT.

PRODUCTION.

So far as can be learned no true flint or chert has been produced for consumption as crushed or ground silica or for use as pebbles in grinding mills in the United States. The manufacture of flint, chert, and quartzite blocks for tube mill lining is reported in the chapter on abrasive materials.

IMPORTS.

The Department of Commerce records imports of "flint, flints, and flint stones, unground," from several countries. These imports are partly flint pebbles for use in grinding mills and partly material for such uses as are listed in this report. The separation or classification of these materials, which are represented by the following figures, is impossible. The imports of flint "for consumption" into the United States in 1916 were valued at $313,120, compared with $274,904 in 1915, $432,694 in 1914, $324,662 in 1913, and $289,904 in 1912. A detailed table of imports of flint pebbles of various kinds, by countries, and a discussion of domestic substitutes for foreign flint pebbles, is given in the chapter on abrasives in Mineral Resources for 1916.

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PEAT.

By James S. Turf.

UTILIZATION OF PEAT IN THE UNITED STATES.

Peat was used in the United States in 1916 mainly for fertilizer and soil builder and as stock food. Small quantities were used for peat litter and fuel, and, as was predicted in the report for 1915, very little peat fuel was produced in this country in 1916.

The most successful industry based on peat so far attempted in the United States is that of preparing peat for use as a fertilizer or as a filler for chemical fertilizers. Black, thoroughly decomposed peat is most satisfactory for all fertilizer uses, as such peats are generally heavier and more compact and contain more nitrogen and less fibrous material than the brown types.

There was an increase of 26 per cent in the production of peat used for fertilizer in 1916 over the output in 1915. Part of the increase is accounted for by the use of peat in the cultivation of lawns, and it is expected that this use will still further increase. Owing to the intensive cultivation of crops in parts of this country, it would seem that now is the time for peat operators to make better known the importance of peat for agricultural purposes and thus aid in relieving the shortage of other fertilizer materials.

The production of peat for fertilizer and fertilizer filler during 1916, as reported, was 48,106 short tons, valued at $336,004, compared with 38,304 short tons, valued at $258,447, in 1915. The selling prices given varied widely according to the grade of the product, the uses to which it was to be put, and the quantity and quality of the materials added. The lowest price per ton reported was $3, the highest $22, and the average about $7.

The following table shows that in only one year, 1911, since these figures were first published by the Geological Survey, has the quantity of peat for fertilizer been greater than in 1916. The value of peat produced for fertilizer was greater in 1916 than in any other year.

Peat used for fertilizer produced in 1908–1916.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1908	23,000	a $121,210	1913	28,460	$169,600
1909	26,768	118,891	1914	37,729	249,899
1910	37,024	140,209	1915	38,304	258,447
1911	51,733	257,204	1916	48,106	336,004
1912	41,080	186,022			

a Estimated.

Requests for information regarding the use of peat strictly as a fertilizer should be addressed to the Bureau of Plant Industry, Washington, D. C.

Two firms reported the production of peat for stock food, the total amounting to 4,300 short tons, valued at $32,250, at an average

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price per ton of $7.50. The quantity showed an increase of 320 tons over that of 1915, in spite of the fact that production in 1916 was reported curtailed because manufacturers were unable to secure molasses, munition manufacturers having taken the supply of molasses at a price that manufacturers of stock food could not afford to pay. It is stated that this peat is used to overcome the bad effects, such as bloating, of molasses on the digestive organs of stock and that it practically takes the place of charcoal.

No peat litter has been produced in the United States for several years. As in previous years, however, a certain quantity was imported in 1916 under the name "peat moss." The entire importation was 3,042 short tons, valued at $27,859, or $9.16 a ton, an increase in value per ton over 1915 of $2.75, but a decrease in total quantity of 4,472 tons and in total value of $20,283. The imports of "peat moss" have been steadily declining for several years.

PRODUCTION.

In 1916 Robert Ranson, of St. Augustine, Fla., reported the manufacture and sale in commercial quantities of bacterized peat for use as a fertilizer. After being taken from the bog the peat was ground finely, neutralized, and then inoculated with nitrifying bacteria. It is said that soil enriched by this material yielded more than double the crops that could be obtained from land fertilized with peat not so treated. Several other firms engaged in the production of peat fertilizer reported additions and improvements to their plants.

The total number of firms reporting production in 1916 was 13, all but one of which sold peat for fertilizer. Two also sold peat for stock food. One sold a small quantity of peat for fuel. The 9 firms that furnished data for 1915 furnished data also for 1916, and 4 firms reported that were not represented in 1915.

The plants known to be at work during the year were distributed as follows: Maine, 1; Massachusetts, 1; New York, 2; New Jersey, 4; Pennsylvania, 1; Florida, 1; Indiana, 1; Illinois, 2.

The quantity of peat products made and used in the United States in 1915 and 1916, so far as these have been reported, are given below.

Peat produced, imported, and consumed in the United States in 1915 and 1916.

Use.	Production.		Imports.		Consumption.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1915.						
Fertilizer and fertilizer filler	38,304	$258,447	.....	.....	38,304	$258,474
Stock food	3,980	30,090	.....	.....	3,980	30,090
Peat moss litter	.....	.....	7,514	$48,142	7,514	48,142
	42,284	288,537	7,514	48,142	49,798	336,679
1916.						
Fertilizer and fertilizer filler	48,106	336,004	.....	.....	48,106	336,004
Stock food	4,300	32,250	.....	.....	4,300	32,250
Miscellaneous	100	850	.....	.....	100	850
Peat moss litter	.....	.....	3,042	27,859	3,042	27,859
	52,506	369,104	3,042	27,859	55,548	396,963

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MICA.

By WALDEMAR T. SCHALLER.

PRODUCTION AND CONSUMPTION.

The total value of the domestic mica (muscovite) produced and sold in 1916 was $594,391, the highest value recorded by the United States Geological Survey. The value of the sheet mica produced in 1916 was also the highest, but the production of scrap mica has been exceeded in previous years. The total quantity of mica produced in 1916 was exceeded by the production in 1900, 1909, 1910, and 1913. Except for 1912, 1914, and 1915 the quantity of sheet mica produced was the smallest since 1904.

The production came from 12 States, North Carolina, New Hampshire, South Dakota, Virginia, Idaho, Alabama, Georgia, South Carolina, New York, Connecticut, Colorado, and Pennsylvania, named in the order of the value of their output. Texas reported a little mica taken out but not sold. A total of 109 tons of mica were mined but not sold in the States of Alabama, Connecticut, Georgia, New Hampshire, Texas, and Idaho.

Percentage of production of mica in 1916 by States.

State.	Quantity.		Value.
	Sheet.	Scrap.	
North Carolina	63	62	71
New Hampshire	14	16	13
South Dakota	13	12	10
Virginia	5	4	4
Idaho, Alabama, Georgia, South Carolina, New York, Connecticut, Colorado, Pennsylvania	[a] 5	[b] 6	[c] 2
	100	100	100

[a] Idaho, Alabama, Georgia, South Carolina, and New York. No single State over 2 per cent.
[b] Idaho, Alabama, South Carolina, New York, Connecticut, Colorado, and Pennsylvania. No single State, except Idaho, over 2 per cent.
[c] No single State over 1 per cent.

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The total production of mica in North Carolina in 1916 was valued at $422,580, as compared with $300,593 in 1915; the production reported consisted of 546,553 pounds of sheet mica, valued at $380,700, and 2,755 tons of scrap mica, valued at $41,880. The production of sheet mica in 1915 amounted to 281,074 pounds, valued at $266,650, and of scrap mica to 2,840 tons, valued at $33,943. A large percentage of the mica from North Carolina is reported as cut mica, ready for the trade, and therefore is given a much higher value than the uncut or run-of-mine mica reported from other States.

The production in New Hampshire in 1916 was valued at $75,239, as compared with $66,971 in 1915; the production reported consisted of 125,502 pounds of sheet mica, valued at $64,386, and of 724 tons of scrap mica, valued at $10,853. The production of mica in 1915 amounted to 96,685 pounds of sheet mica, valued at $59,414, and of 516 tons of scrap mica, valued at $7,557.

The production of South Dakota was valued at $59,770, and consisted of 115,39½ pounds of sheet mica, valued at $49,298, and of 527 tons of scrap mica, valued at $10,472.

Mica produced and sold in the United States, 1880–1916.

Year.	Sheet mica, including rough-trimmed and cut.		Scrap mica.		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Short tons.*		
1880	81,669	$127,825	.....	.....	$127,825
1881	100,000	250,000	.....	.....	250,000
1882	100,000	250,000	.....	.....	250,000
1883	114,000	285,000	.....	.....	285,000
1884	147,410	368,525	.....	.....	368,525
1885	92,000	161,000	.....	.....	161,000
1886	40,000	70,000	1,000	$10,000	80,000
1887	70,000	142,250	2,000	15,000	157,250
1888	48,000	70,000	.....	.....	70,000
1889	49,500	50,000	196	2,450	52,450
1890	60,000	75,000	496	6,200	81,200
1891	75,000	100,000	.....	.....	100,000
1892	75,000	100,000	.....	.....	100,000
1893	51,111	80,629	156	8,300	88,929
1894	35,943	43,793	191	8,595	52,388
1895	84,408	50,381	148	5,450	55,831
1896	49,156	65,441	222	1,750	67,191
1897	82,676	80,774	740	14,452	95,226
1898	129,520	103,534	3,999	27,564	131,098
1899	108,570	70,587	1,505	30,878	101,465
1900	456,283	92,758	5,497	55,202	147,960
1901	380,060	98,859	2,171	19,719	118,578
1902	373,266	83,843	1,400	35,006	118,849
1903	619,600	118,088	1,659	25,040	143,128
1904	668,358	109,462	1,096	10,854	120,316
1905	924,875	160,732	1,126	17,856	178,588
1906	1,423,100	252,248	1,489	22,742	274,990
1907	1,060,182	349,311	3,025	42,800	392,111
1908	972,964	234,021	2,417	33,904	267,925
1909	1,809,582	234,482	4,090	46,047	280,529
1910	2,476,190	283,832	4,065	53,265	337,097
1911	1,887,201	310,254	3,512	45,550	355,804
1912	845,483	282,823	3,226	49,073	331,896
1913	1,700,677	353,517	5,322	82,543	436,060
1914	656,933	278,540	3,730	51,416	329,956
1915	553,821	378,259	3,959	50,510	428,769
1916	885,863	524,485	4,433	69,906	594,391

This table has been compiled from the figures reported by the producers. The total value therefore includes that of the cut mica ready for the trade, the uncut mica, the scrap, and the run-of-mine mica.

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The run-of-mine mica is sold either in bulk at so much per ton or on contract at a fixed price per ton. The prices paid represent the value of the mica as it is taken from the mine and not the value of the finished cut mica ready for the trade. The finished cut mica brings a much higher price, as it is ready to be used and has had a considerable amount of money spent on it. It is obviously inconsistent to add together the value of mica of two greatly different classes, yet this procedure is the only one that can at present be followed. The total production for the United States in 1916 of cut sheet mica was 315,174 pounds, valued at $410,693, an average price of 1.30 a pound. The total production of uncut sheet mica, which includes an estimated percentage of the sheet yield of run-of-mine mica, was 550,689 pounds, valued at $113,792, or an average price of only $0.21 a pound. Yet this uncut mica needs only to be cut in order to have its value materially increased.

The figures of production of mica in the United States, as reported to the United States Geological Survey, do not show any noteworthy change in the quantity (9,102 short tons) produced in the two years 1915 and 1916, as compared with the quantity (9,821 short tons) produced in the two years immediately preceding 1914. In 1914 the production was 4,008 short tons. Neither was there any significant change in the same years in consumption—that is, production plus imports minus exports. About 80 to 90 per cent of the total domestic consumption of mica is mined in the United States, the remainder being imported from Canada and from India, either direct or through England. The imports have decreased, those for 1912 and 1913 amounting to nearly 2,500 short tons and those for 1915 and 1916 amounting to about 1,500 short tons. In 1914 the imports were 611 short tons. In round numbers 11,000 short tons of mica were consumed in 1915 and 1916, as against 12,000 short tons in 1912 and 1913. In 1914 approximately 5,000 short tons were consumed.

The following table shows the consumption of mica in the United States from 1900 to 1916. The figures for the years after 1914, as compared with those before 1914, show no greater variation than can be found in like periods of years.

The figures represent the total quantity of mica produced in this country. The incentive for this production is the content of sheet mica. The domestic production and consumption of mica in 1900 has been exceeded only in 1913. From 1901 to 1908, inclusive, both production and consumption were smaller than in the following years. The maximum was reached in 1913. From 1914 to 1916 both production and consumption have shown a steady increase, although the figures have not yet reached the amounts credited to 1909, 1910, or 1913. A comparison of the figures for the years 1900–1916 does not clearly show any effect of the war on the quantity of mica produced or consumed.

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Mica consumed in the United States, 1900–1916, in short tons.

Year.	Production.	Imports.	Consumption.	Percentage of consumption represented by production.
1900	5,725	978	6,703	85
1901	2,351	839	3,190	74
1902	1,587	1,126	2,713	58
1903	1,969	712	2,681	73
1904	1,430	574	2,004	71
1905	1,588	797	2,385	67
1906	2,201	1,533	3,734	59
1907	3,555	1,169	4,724	75
1908	2,903	274	3,177	91
1909	4,995	943	5,938	84
1910	5,303	[a] 1,015	[a] 6,318	84
1911	4,456	[a] 750	[a] 4,988	89
1912	3,649	[a] 1,166	[a] 4,624	79
1913	6,172	[a] 1,265	[a] 7,264	85
1914	4,008	[a] 611	[a] 4,371	92
1915	4,236	[a] 613	[a] 4,805	88
1916	4,866	[a] 856	[a] 5,658	86

[a] Estimated.

However, only a small percentage of all the mica mined in the United States eventually becomes sheet. The percentage of sheet mica (rough-trimmed and cut) obtained from the total domestic production of mica is as follows:

Percentage of sheet mica (rough-trimmed and cut) obtained from the total domestic production of mica, 1900–1916.

1900	4	1906	32	1912	12
1901	8	1907	15	1913	14
1902	12	1908	17	1914	7
1903	15	1909	18	1915	7
1904	23	1910	23	1916	9
1905	29	1911	21		

The imported mica is largely trimmed sheet, and if a comparison is made between the production and consumption of sheet mica, then the percentage of consumption represented by domestic production of sheet mica is much smaller than that shown in the table above, being in recent years about 40 per cent.

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Sheet mica consumed in the United States, 1900–1916, in short tons.

Year.	Production.	Imports.	Consumption.	Percentage of consumption represented by production.
1900	228	978	1,206	19
1901	180	839	1,019	18
1902	187	1,120	1,313	14
1903	310	712	1,022	30
1904	334	574	908	37
1905	462	797	1,259	37
1906	712	1,533	2,245	32
1907	530	1,169	1,699	37
1908	486	274	760	64
1909	905	943	1,848	49
1910	1,238	981	2,219	56
1911	944	664	1,598	59
1912	423	995	1,405	30
1913	850	a 1,120	a 1,946	44
1914	278	a 409	a 673	41
1915	277	a 441	a 701	40
1916	433	a 675	a 1,071	40

a Estimated.

The domestic production of sheet mica for the five-year period from 1912 to 1916 is larger than for the five-year period from 1900 to 1904, but is much smaller than for any other five-year period since 1900. The sheet mica consumed in the last five years is about the

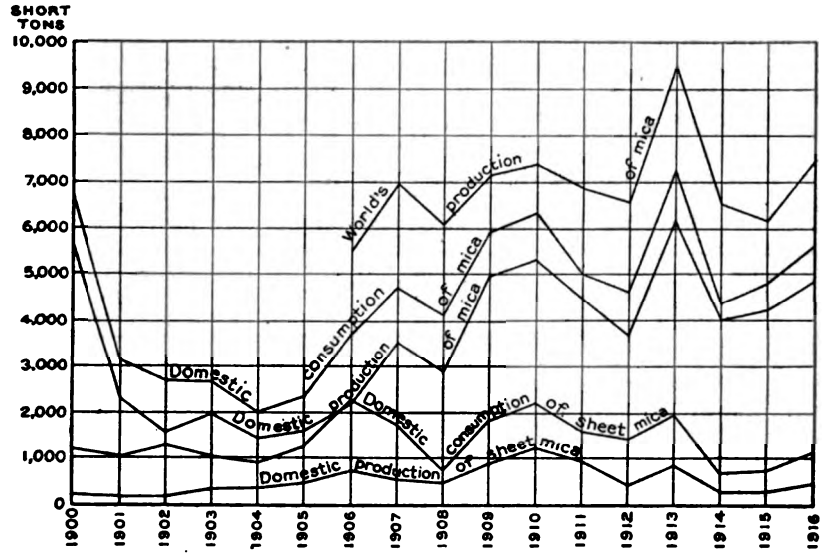

FIGURE 5.—Production and consumption of mica in the United States, 1900–1916.

same in quantity as that consumed in 1900–1904, but is less than for other like periods.

The relation of domestic production to consumption, in quantity, is shown graphically in figure 5, which gives the production and consumption of mica and of sheet mica from 1900 to 1916. For comparison the world's production of mica from 1906 to 1916 is also shown. The lines for production and for consumption indicate that

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the war has had no marked effect on the quantity of mica produced. The abnormally large production of 1913 would doubtless have been followed by decreased production in 1914 and in 1915, even if peace had continued. The relation of consumption and production of mica is remarkably constant; that for sheet mica shows more variation. It is to be noted that the United States consumes about 75 per cent of the world's production of mica. In 1912 it was 73 per cent; in 1913 it was 78 per cent; in 1914 it fell to 69 per cent, but it recovered to 79 per cent in 1915, and dropped to 76 per cent in 1916.

WORLD'S PRODUCTION.

The world's production of mica amounts annually to about 7,000 short tons, valued at the mines at about $1,000,000. This value is materially increased by the mere process of splitting, sorting, and rough trimming. The value of the exports of such trimmed mica in India is about three times the value of the crude mica at the mines.

The following table represents practically the world's production of mica mined for its sheet content. The table excludes therefore the mica scales recovered from the clay workings in Cornwall and Devon, England, and lepidolite, a lithium mica used as a source of lithium products. As already noted in the discussion of production of domestic mica, the incentive for the mining of this mica is its sheet value, although sheet mica makes only a small percentage of the annual production.

The quantity of mica produced in the world from 1896 to 1916 is shown in the following table. The United States, India, and Canada are the chief mica-producing countries, the output of the other countries being negligible. A second table, immediately following, shows the production of the other countries.

World's production of mica, 1896–1916, in short tons.

Year.	United States.	India.[a]	Canada.	Other countries.	Total.
1896	247	373	(b)	3	.....
1897	781	775	(b)	59	.....
1898	4,064	308	(b)	5	.....
1899	1,559	694	(b)	[c] 1	.....
1900	5,725	1,026	(b)	[c] 1	.....
1901	2,351	1,274	(b)	[c] 1	.....
1902	1,587	1,143	(b)	85	.....
1903	1,969	1,206	(b)	39	.....
1904	1,430	1,108	(b)	[c] 13	.....
1905	1,588	1,282	(b)	15	.....
1906	2,201	2,627	574	49	5,451
1907	3,555	2,610	774	54	6,993
1908	2,903	2,677	436	125	6,141
1909	4,995	1,645	369	122	7,131
1910	5,303	1,135	758	173	7,369
1911	4,456	1,695	590	207	6,948
1912	3,649	2,192	580	217	6,638
1913	6,172	2,288	1,104	[d] 11	9,575
1914	4,008	2,026	595	[d] 20	6,649
1915	4,236	1,357	[e] 515	[d] 56	6,164
1916	4,866	[e] 1,900	[e] 984	[d] 75	7,725

[a] The figures for the years 1896 to 1903 are export figures, as no figures of production are available. The figures for the years 1904 to 1915 represent production and not export.
[b] No figures available.
[c] Approximate. For some years the quantity is only a small fraction of a ton.
[d] Incomplete, as no figures of production are available for most of the countries.
[e] Preliminary estimate.

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The figures given under "Other countries" are made up from those contained in the following table:

Minor quantities of mica produced by certain countries, 1896–1916, in short tons.

Year.	Brazil.	Argentina.	German East Africa.	Transvaal.	Natal and British Nyasaland.	Madagascar.	Ceylon.	Australia.	Total.
1896	.....	.....	.....	.....	.....	.....	.....	a 3	3
1897	.....	.....	.....	.....	.....	.....	9	a 50	59
1898	.....	.....	.....	.....	.....	.....	4	a 1	5
1899	.....	.....	.....	.....	.....	.....	.....	½	1
1900	.....	.....	.....	.....	.....	.....	0	(b)	1
1901	.....	.....	.....	.....	.....	.....	1	.....	1
1902	12	.....	16	.....	c 57	.....	(b)	.....	85
1903	8	.....	(d)	.....	c 30	.....	½	.....	39
1904	12	.....	(d)	.....	.....	.....	(b)	.....	13
1905	0	.....	15	.....	.....	.....	0	.....	15
1906	16	.....	27	.....	.....	.....	6	.....	49
1907	5	.....	26	.....	.....	.....	23	.....	54
1908	23	1	87	.....	.....	½	13	(b)	125
1909	5	12	105	(e)	.....	0	0	.....	122
1910	2	21	120	4	25	½	0	.....	173
1911	9	14	110	1	73	(b)	0	.....	207
1912	13	7	172	4	21	0	0	.....	217
1913	11	(d)	(d)	(d)	(d)	(d)	(d)	.....	e 11
1914	20	1	(d)	0	(d)	(d)	(d)	.....	e 20
1915	56	0	(d)	2	(d)	(d)	(d)	.....	e 56
1916	59	f 3	(d)	13	(d)	(d)	(d)	.....	e 75

a Estimated. b Small production. c Natal. d No information available. e Incomplete. f First 9 months only.

Figure 6 shows graphically the quantity of mica produced in the world from 1896 to 1916. The production in Canada shows no great fluctuation. Unfortunately, no figures of the quantity mined before 1906 are available. The production of India is shown from 1904 to

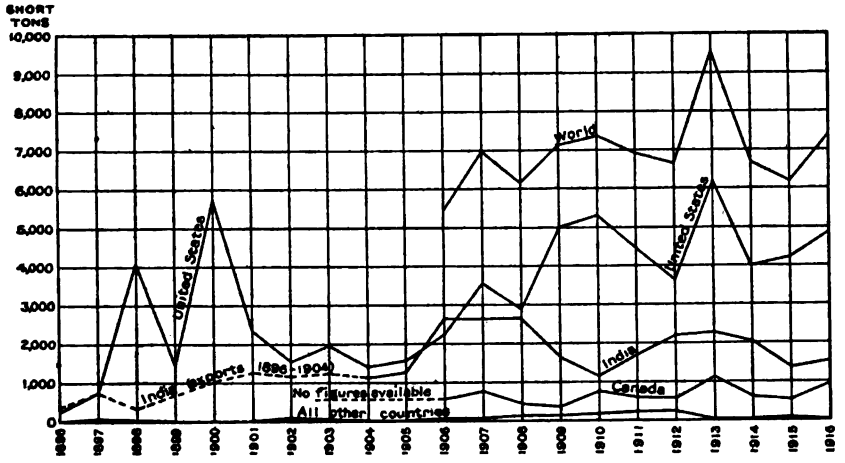

FIGURE 6.—World's production of mica, 1896–1916. The world's production for 1916, estimating 1,500 short tons for India, is about 7,400 short tons.

1916; for the period before 1904 only export figures are available. India exceeded the United States in production in 1906, but only by a small quantity. The quantity produced in the United States shows very great variation, especially from 1897 to 1901, when for several

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years it remained fairly constant, reaching a high point in 1907, again in 1910, and the maximum in 1913.

Percentages of world's production of mica represented by domestic production and by domestic consumption, 1906–1916.

Year.	World's production in short tons.	Percentage of domestic production.	Percentage of domestic consumption.
1906	5,451	40	69
1907	6,993	51	68
1908	6,141	47	52
1909	7,131	70	85
1910	7,369	72	86
1911	6,948	64	75
1912	6,638	55	73
1913	9,575	64	78
1914	6,649	60	69
1915	6,164	69	79
1916	[a] 7,725	63	73

[a] Estimated, by assuming a production of about 1,800 short tons for India.

Value of world's production of mica.

Year.	United States.	India.	Canada.	Other countries.	Total.
1896	$67,191	.....	.....	$1,616	.....
1897	96,226	.....	.....	29,224	.....
1898	131,098	.....	.....	3,149	.....
1899	101,465	.....	$163,000	2,628	.....
1900	147,960	.....	166,000	19	.....
1901	118,578	.....	160,000	365	.....
1902	118,849	.....	135,904	42,480	.....
1903	143,128	.....	177,857	17,806	.....
1904	120,316	.....	160,777	4,131	.....
1905	178,588	$406,328	178,225	8,831	$771,982
1906	274,990	[a]	303,913	25,557	.....
1907	392,111	[a]	312,509	30,072	.....
1908	267,925	[a]	139,871	59,443	.....
1909	280,529	185,691	147,782	67,649	681,651
1910	337,097	264,869	190,385	121,433	913,784
1911	355,804	343,341	128,677	123,181	951,003
1912	331,896	473,442	143,976	130,608	1,079,922
1913	436,060	561,249	194,304	8,233	1,199,846
1914	329,956	423,690	109,061	15,751	883,458
1915	428,769	360,797	[b] 89,387	36,200	915,153
1916	594,391	[a]	[b] 177,763	56,080	.....

[a] No figures available. [b] Preliminary estimate.

The figures given under "Other countries" are made up from those in the following table:

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Value of minor quantities of mica produced by certain countries, 1896–1916.

Year.	Brazil.	Argentina.	German East Africa.	Transvaal.	Natal and British Nyassaland.	Madagascar.	Ceylon.	Australia.
1896								$1,616
1897							$5,188	24,036
1898							2,662	457
1899							2,380	243
1900								19
1901							365	
1902	$4,258		$9,600		$28,500		122	
1903	2,611				15,000		195	
1904	3,941						190	
1905			8,831					
1906	6,417		16,707				2,433	
1907	8,669		16,551				4,852	
1908	5,806	$260	51,366			$243	1,718	50
1909	1,597	3,079	62,973	$973				
1910	1,184	30,172	77,864	691	12,463	243		
1911	3,302	3,820	84,745	1,217	33,370	19		
1912	5,455	1,820	117,161	1,767	9,360			
1913	3,233							
1914	14,207	1,544						
1915	35,470			730				
1916	54,341	a1,739		5,767				

a First 9 months.

The foregoing figures refer to mica which is mined for its sheet content, but which in its final form yields only a small percentage of sheet mica. If the production of India, Canada, and all other foreign countries is considered as sheet mica, then the production of sheet mica in the United States becomes only a small percentage of the world's production, ranging for the last five years from 11 to 23 per cent. In fact, the table showing sheet mica consumed in the United States (p. 295) indicates that the imports of sheet mica exceed the domestic production of sheet mica for all years since 1900, except 1908, 1910, and 1911.

It is impossible to give accurate figures of the world's production of sheet mica, for the two reasons that the sheet mica reported by different countries is in very different stages of treatment and that the reports of foreign Governments do not separate their figures of production of mica into those for sheet mica and scrap mica.

The table shown below has been compiled from certain data and a number of assumptions. The total reported production of mica for India is considered sheet. From the detailed figures of mica imported from Canada, it has been estimated that one-half of the total reported production of mica from Canada represents sheet. A similar estimate is made for all other countries. The quantities given in the table are therefore only estimates. Perhaps their greatest value lies in comparisons, for although in the 5-year period 1912–1916, according to the figures published by the different Governments, the United States produced 63 per cent of the total mica mined for its sheet content, yet it produced in the same time only about 16 per cent of the world's sheet mica. The United States consumed in that period, however, 41 per cent of the world's sheet mica.

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Estimated world's production of sheet mica (rough-trimmed and cut), 1906–1916, in short tons.

Year	United States.	India.	Canada.	All other countries.	Total.	Percentage of total represented by domestic production.	Percentage of total represented by domestic consumption.
1906	712	2,627	287	25	3,651	20	61
1907	530	2,610	387	27	3,554	15	48
1908	486	2,677	218	63	3,444	14	22
1909	905	1,645	185	61	2,796	32	66
1910	1,238	1,135	379	87	2,839	44	78
1911	944	1,695	295	104	3,038	31	53
1912	423	2,192	290	109	3,014	14	47
1913	850	2,288	552	6	3,696	23	53
1914	278	2,026	298	10	2,612	11	26
1915	277	1,357	258	28	1,920	14	37
1916	433	1,800	492	38	2,763	16	39

PRICES.

The following table shows by years the variations in value and price of the mica marketed in the United States from 1900 to 1916:

Prices and value of domestic mica marketed in the United States, 1900–1916.

Year.	Total value.	Average price per short ton of all mica mined.	Average price per pound of sheet mica.
1900	$147,960	$26	$0.20
1901	118,578	50	.27
1902	118,849	75	.22
1903	143,128	73	.19
1904	120,316	84	.16
1905	178,588	112	.17
1906	274,990	125	.18
1907	392,111	110	.33
1908	267,925	92	.24
1909	280,529	56	.13
1910	337,097	64	.11
1911	355,804	80	.17
1912	331,896	91	.33
1913	436,060	71	.21
1914	329,956	82	.50
1915	428,769	101	.68
1916	594,391	122	.61

The lower price of 61 cents for sheet mica in 1916, as compared with 68 cents in 1915, is due to the large output of punch or washer sheet mica produced in 1916. The average price of mica per ton in 1916 ($122) has been exceeded only once—in 1906.

The war has not had any marked effect on the quantity of mica produced in the United States, but, in line with the increase in the prices of commodities in general, mica in 1916 reached a value much higher than in any preceding year. The value ($594,391) is an increase of 36 per cent over the previous high value ($436,060) in 1913, and an increase of 39 per cent over the value ($428,769) in 1915. The value of the mica imported in 1916 ($1,071,356) is the highest recorded.

The variation in the average prices of domestic mica is shown graphically in figure 7. By comparing figure 7 with figure 5, which

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represents the quantity of mica produced, it can be seen that an appreciable increase in the price of domestic mica has taken place since 1914, without a corresponding increase in the quantity produced.

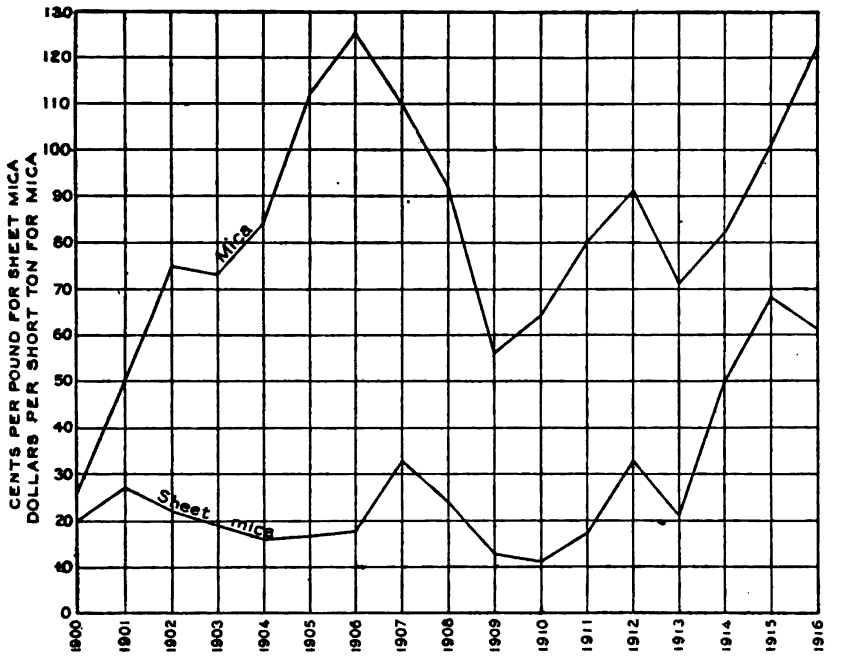

FIGURE 7.—Variation in the average prices of domestic mica, 1900–1916.

The following table gives the average prices paid in the South for rough-trimmed sheet mica of good quality, split and sorted to cut the sizes indicated.

Average prices per pound paid in the South for rough-trimmed sheet mica of good quality, split and sorted to cut the sizes indicated.

Size (in inches).	1913	1914	1915	1916	1917 (February).[a]
Punch[b]	$0.035	$0.03	$0.04	$0.05	$0.05
1½ by 2	.12	.10	.20	.30	.35
2 by 2	.30	.25	.40	.55	.70
2 by 3	.70	.65	.70	.90	1.00
3 by 3	1.15	1.00	1.00	1.35	1.50
3 by 4	1.35	1.20	1.25	1.70	1.75
3 by 5	1.70	1.50	1.50	1.95	2.10
4 by 6	2.25	2.00	2.10	2.85	3.00
6 by 6	3.00	2.70	2.80	3.50	3.50
6 by 8	4.00	3.60	3.50	5.00	4.50
8 by 10	6.00	5.40	5.20	7.50	7.00
Average price per square inch (excluding punch)	.09	.08	.08	.11	.11

[a] The figures for February, 1917, are those furnished by a single company; they are not average prices.
[b] Punch mica will yield only disks or washers 1½ inches in diameter if stained and 1¼ inches in diameter if clear.

The prices given above apply only to good sheet mica of the first and second quality. The mica must be nearly free from spots and

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stains for mica with such flaws is worth much less, as is shown in the following table, which includes the average prices according to quality paid in the South at the beginning of 1917.

Grades and prices per pound of sheet mica in the southern United States, early part of 1917.

Grade.	Size (in square inches).	Approximate corresponding sizes used as bases of purchase in the South.	Price according to quality.		
			No. 1 and No. 2 quality.	Spotted or slightly clay stained.	Black "specked," heavily clay stained.
Extra special	48 and up	8 by 10	$7.00	$5.00	$3.00
Special	36 to 48	6 by 8	4.50	3.00	2.50
1	24 to 36	6 by 6	3.50	2.50	2.00
2	14 to 24	4 by 6	3.00	2.25	1.75
		3 by 5	2.10	1.75	1.40
3	9 to 14	3 by 4	1.75	1.35	1.20
		3 by 3	1.50	1.10	.90
4	6 to 9	2 by 3	1.10	.75	.60
5	3 to 6	2 by 2	.70	.45	.20
6	— to 3	1½ by 2	.35	.15	
		Punche	.05	.045	.04

[a] Punch mica will yield disks 1½ inches in diameter if stained and 1¼ inches in diameter if clear.

As the table shows, size is the principal basis for grading rough-trimmed sheet mica after it is sorted for quality. The prices are those offered per pound for rough-trimmed sheet mica, sorted to cut the sizes and qualities indicated.

A comparison of these prices with those of 1915 shows that the greatest increase has been made in the prices of sheet mica of the first and second quality

The following prices per pound are reported [1] to have been paid in 1916 in Canada for standard thumb-trimmed phlogopite:

1 by 1 inch, $0.055–$0.065.
1 by 2 inches, $0.11–$0.14.
1 by 3 inches, $0.16–$0.20.
2 by 3 inches, $0.40–$0.45.
2 by 4 inches, $0.65.
3 by 5 inches, $0.90.
4 by 6 inches, $1.25.

The average price of domestic scrap mica in 1916, as deduced from the total production, was $15.77 a short ton, as compared with $12.76 a ton in 1915.

The variations in prices reported from different States in different years is largely due to the stage of manufacture in which the mica is reported. The mica sold in the rough at the mines necessarily includes a large proportion of scrap, and the prices are accordingly much lower than those for trimmed sheet mica reported by companies having trimming plants.

IMPORTS.

The unmanufactured and cut or trimmed sheet mica imported for consumption in the United States during 1916, as reported by the

[1] Report on mining operations in the Province of Quebec, 1916, Department of Colonisation, Mines, and Fisheries, Mines Branch, Quebec, 1917.

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Bureau of Foreign and Domestic Commerce, Department of Commerce, was valued at $1,067,936. In 1916 there were imported 181 tons of ground mica, valued at $3,420. The value of the imports of sheet mica is the highest ever recorded.

Mica imported for consumption in the United States, 1900–1916.

Year.	Sheet.				Ground.		Total.	
	Unmanufactured.		Cut or trimmed.					
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*		*Pounds.*		*Pounds.*	
1900	1,892,000	$290,872	64,391	$28,688	.....	.....	1,956,391	$319,560
1901	1,598,722	299,065	78,843	35,989	.....	.....	1,677,565	335,054
1902	2,149,557	419,362	102,299	46,970	.....	.....	2,251,856	466,332
1903	1,355,375	288,783	67,680	29,186	.....	.....	1,423,055	317,969
1904	1,085,343	241,051	61,986	22,663	.....	.....	1,147,329	263,714
1905	1,506,382	352,475	88,188	51,281	.....	.....	1,594,570	403,756
1906	2,984,719	983,981	82,019	58,627	.....	.....	3,066,738	1,042,608
1907	2,226,460	848,098	112,230	77,161	.....	.....	2,338,690	925,259
1908	497,332	224,456	51,041	41,602	.....	.....	548,373	266,058
1909	1,678,482	533,218	168,169	85,595	.....	.....	1,846,651	618,813
1910	1,424,618	460,694	536,905	263,831	(a)	$1,298	(a)	725,823
1911	1,087,644	346,477	241,124	155,686	(a)	3,389	(a)	505,552
1912	1,900,500	649,236	88,632	99,737	b 343,824	b 6,611	2,332,956	755,584
1913	2,047,571	751,092	(a)	191,926	290,757	4,765	(a)	947,783
1914	360,888	168,591	(a)	456,805	404,848	4,088	(a)	629,484
1915	433,822	240,449	(a)	447,962	344,040	3,858	(a)	692,269
1916	703,832	421,856	(a)	646,080	362,000	3,420	(a)	1,071,356

a Quantity not reported. b Figures cover only last 6 months of 1912.

The imports of mica came from the following countries, arranged according to decreasing value: For the last six months of 1914, England and India, Canada, Germany, China, Guatemala, and Cuba; for the first six months of 1915, England and India, Canada, the Netherlands, Germany, Norway, Brazil, Guatemala, and Japan; for the last six months of 1915, England and India, Canada, Brazil, Norway, Guatemala, Germany, and Scotland; and for the year 1916, England and India, Canada, Brazil, Argentina, France, and Scotland. The country named is not necessarily the country of origin of the mica.

EXPORTS.

The exports of mica went chiefly to Canada, the United Kingdom, Japan, Sweden, France, Australia, Dutch East Indies, and Spain. In addition to these countries mica was exported in 1916 to Italy, the Netherlands, Russia, Costa Rica, Guatemala, Honduras, Nicaragua, Panama, Mexico, Newfoundland, Barbados, Jamaica, Trinidad and Tobago Island and other British West Indies, Cuba, the Dominican Republic, Argentina, Brazil, Chile, Colombia, Ecuador, French Guiana, Peru, Venezuela, China, Siam, the Philippine Islands, New Zealand, British South Africa, and Egypt.

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Mica exported from the United States, 1910–1916.

Year.	Unmanufactured.		Manufactured.	Total value.
	Quantity (pounds).	Value.	Value.	
1910				$20,543
1911	415,862	$15,649	$20,267	35,916
1912	356,601	14,936	25,876	40,812
1913	296,711	14,175	48,009	62,184
1914	467,451	23,145	27,751	50,896
1915	54,183	5,118	33,915	39,033
1916	63,168	4,544	74,127	78,671

USES.

The different uses to which mica is put depend on its form—whether in sheets or in powder. Sheet mica is used in the electrical industry, for glazing, and to some extent for other purposes. Ground mica is used chiefly in the decorative trades and in insulation.

Sheet mica finds its greatest use in the electrical industry, where an insulating, noninflammable material is necessary. It is used in sheets and as washers and disks in dynamo-electric machinery, electric-light sockets, spark plugs, insulators, guards in rheostats, fuse boxes, and telephones. Flexible cloth and tape, covered with mica, find varied uses in electrical apparatus. Sheet mica is used for glazing the fronts of stoves and for making lamp chimneys and lamp shades. It is also used in spectacles, automobile shields, phonograph diaphragms, in windows where glass would be broken, and in lantern transparencies.

Ground mica is used for decoration in wall paper, to which it gives luster and brightness; in fancy paints, ornamental tiles, concrete, rubber goods, pipe and boiler coverings, insulating compounds, fireproof paints and coverings, patent roofing material, molded mica (ground mica mixed with shellac), and calico printing; as absorbent for nitroglycerin in the manufacture of "mica powder," in tempering steel; to a large extent as a lubricant for wooden bearings, or, mixed with oil, as a lubricant for metal bearings; and as a filler for various products. Tar and other roofing papers are coated with coarsely ground mica to prevent sticking when they are rolled for shipment. A possible value of ground mica as a chemical source of potash salts is indicated in a recent Geological Survey report.[1]

It is understood that sheet mica has come to be of importance as a war mineral through its use abroad as windows in masks worn for defense against asphyxiating gases, and for other uses where a transparent, noninflammable, nonshattering material is necessary, as in automobile goggles and in windows for armored cars.

Several trade names have been given to the mica products described below.

[1] Butler, B. S., Potash in certain copper and gold ores, with a note on muscovite by George Steiger: U. S. Geol. Survey Bull. 620, pp. 227–235, 1916.

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Micanite is a term applied to a mica board made from many small, thin sheets of mica, which are fitted together and built up by successive layers that are cemented with shellac and then subjected to pressure under heat to dry out the shellac. Large sheets thus made are suitable for many electrical purposes.

Silberglimmer (silvery mica) is muscovite which has been heated to a sufficiently high temperature to make it softer and opaque and silvery in appearance. It is also known as annealed mica and finds a use in certain parts of electric apparatus.

Micarta is an artificial mica product developed by the Westinghouse Electric & Manufacturing Co., of Pittsburgh, Pa., and is intended to take the place of hard fiber, glass, porcelain, hard rubber, built-up mica board, rawhide, molded compounds for use in commutators, bushings, brush-holder insulation, noiseless gear blanks, conduits for wiring, spools for spark coil and magnet windings, wireless-coil separators, and water-meter disks. Micarta is a tan-colored hard, homogeneous material that can be sawed, milled, turned, and threaded. Thin sheets can be punched, and it is claimed that it will not warp, expand, or shrink beyond very small limits. Two grades of micarta are made. One, known as bakelite micarta, is infusible and will resist heat to a point at which carbonization of some of the ingredients takes place. It is insoluble in nearly all ordinary solvents, such as alcohol, benzine, turpentine, and weak acid and alkali solutions.

Micamima, prepared by the Crawford Mica Co., of Crawford, Nebr., is a coarsely ground mica used in the manufacture of concrete facing material; mixed with other minerals it is used to give the effect of natural rock, and it may be used for different decorative purposes.

Micolith, prepared by the Texas Mica Co., of Pecos, Tex., is another similar product used to give the effects of natural rock to concrete facings.

Tungash, as the Denver Mining & Manufacturing Co., of Denver, Colo., calls its product, is a bronze-colored, metallic-looking material of value for decoration. The crude biotite mica, altered and hydrated, has a dull greenish-black appearance when mined. On being heated it expands to a light product, which has a rich golden-bronze color and a decidedly metallic luster.

Clinomica is the name given by the American Mica Co., 52 Broadway, New York, to its ground clinochlore, a mineral of the chlorite group. Clinomica possesses essentially the qualities of ground mica, and is used as a dusting material in the rubber and composition-roofing industries, for paints, cements, lubricants, molded electric insulation, and as a filler for various products.

Rimco is mica ground by a nonmetallic process by the Richmond Mica Co., Richmond, Va., for use as a tire powder. It is also used by manufacturers of oils and lubricating greases.

PHLOGOPITE DEPOSITS IN THE UNITED STATES.

For certain pieces of electric machinery muscovite (a silicate of aluminum and potassium with water) is not as suitable as phlogopite (a silicate of aluminum, potassium, and magnesium with flourine

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and water). For use on commutators built up of copper and mica the softer and more elastic phlogopite is better than muscovite, as it has more nearly the same hardness as the copper of the commutator segments; both therefore wear down more evenly.

Phlogopite is not abundant in the United States, and the known localities where it is found in quantity are in New York and New Jersey. An investigation of these phlogopite deposits has been made by the United States Geological Survey, and a special report is in preparation.

In New York State the phlogopite of possible commercial value is found in St. Lawrence County, and although no recent work has been done at most of these places, large sheets were formerly obtained there and the deposits may develop into commercial importance. An occurrence near Oswegatchie showed a large quantity of mica with some good sheet mica.

The New Jersey deposits have been briefly mentioned by Lewis.[1] According to him:

> Mica was mined at several places in New Jersey 25 to 50 years ago. Some of the deposits are now receiving renewed attention that may lead to a revival of the industry. The mineral at all of the mines is phlogopite, or amber mica, although the colors are hardly those suggested by the name "amber," ranging from gray to brownish, and in some of the old reports the mineral was referred to as muscovite. Under the old conditions it was considered inferior on account of its color, and considerable quantities of small sizes and dark-colored sheets of larger size were thrown into the waste. Recently some of this has been recovered from one of the old dumps and sold, and steps are said to have been taken to test some of the workings with a view to their possible operation again.
>
> Two localities in Morris County and two in Warren were the chief places worked in a small way in former years. The Morris County localities are (1) 4 miles west of Morristown, near the Mendham road, and (2) 1 mile south of Mendham; those of Warren County are (1) 3½ miles west of Washington and 1 mile north of Broadway, on the south slope of Scotts Mountain, and (2) 6 miles northeast of Phillipsburg and 3 miles north of Stewartsville.

FOREIGN MICA.

CANADA.

According to a report from Consul F. S. S. Johnson several deposits of muscovite or white mica have been discovered near Kingston, Ontario. He also reports the intention of establishing a plant near Kingston for grinding the abundant dark mica.

Mica deposits in British Columbia, at Tete Jaune Cache, about 35 miles west of the Yellowhead Pass through the Rocky Mountains above the south bank of Fraser River, were worked[2] for a short time in 1914. A series of large granitic pegmatite dikes from 25 to 1,800 feet in width have yielded plates of muscovite, which are reported in large sheets, some of them 19 inches square. About 2 tons of mica were taken out of the Albreda group of claims in 1914. It is said that half of the mica taken out could be trimmed into sheets 2 by 5 inches in size.

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[1] Lewis, J. V., New Jersey Dept. Conservation and Development, Div. Geology, Press Bulletin, February, 1916. Mineral Industry for 1915, p. 501, 1916.

[2] Mica at the Tete Jaune, British Columbia: Canadian Min. Jour., vol. 36, p. 722, 1915.

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BRAZIL.

Mr. Charles P. Storrs, of the Storrs Mica Co., Owego, N. Y., has kindly furnished the information that in some parts of Brazil the mica is similar in quality and texture to the India ruby mica; that small quantities of this mica have been shipped to European markets; but that the industry has not been developed because labor is scarce and not efficient and difficulties of transportation are serious. He also reports that the mica in the section that he visited is found in a rather soft formation and usually in kaolin veins, and that trouble is experienced from excessive rains and fever.

SOUTH AFRICA.

United States Consul Edwin N. Gunsaulus, of Johannesburg, Union of South Africa, reports that the only concern rendering returns to the mines department, the Leydsdorp Mica (Ltd.), of Johannesburg, shipped only 5 tons to London from February to May, 1916.

The only information on mica in the various Provinces of the Union at the disposal of the mines department is contained in the following notes furnished by the various inspectors of mines:

There are very extensive deposits of excellent mica in the Leydsdorp division of the Pietersburg district, Transvaal. So far these have not been seriously exploited, but some tens of tons of mica have at various times been exported and have realized good prices.

In the Cape Province muscovite has been found in pegmatite veins in granite at Alicedale and Middel Water in Prieska. Only rarely can sheets be obtained exceeding a few inches in size, and almost invariably they are bent or crumpled. The granites have been considerably affected by earth movements subsequent to the formation of the pegmatite veins and the mica crystals have in consequence been distorted. Mica has also been worked for at Jackalswater, Namaqualand, and it was understood a cutting machine was at work in that district. The military operations there unfortunately interfered with the further progress of work.

In Natal, mica has been worked in the Umfuli Valley, near Melmoth, and on the Mvuzana River, Fort Yolland, near Eshoe. The last work on the deposit at Fort Yolland was done in 1914. The mica occurs in pegmatite, veining hornblende schist. The pegmatite veins are very irregular and disconnected. They vary in width from a few inches to 8 feet. The mica is found in "books" of from 2 to 6 inches in diameter, and from 1 to 3 inches in thickness, sparsely scattered through the feldspar-quartz pegmatite. A very large amount of waste material must be removed in order to extract the mica, which, although of good color, is frequently cracked and bent, owing to the movements to which the pegmatites have been subjected.

There are no known occurrences of commercial mica in Orange Free State.

INDIA.

It is most difficult to obtain accurate figures of production of mica in India. The export figures naturally do not account for the consumption in India, which has been estimated to amount to at least 400 tons annually; the export figures include, on the other hand, parts of reserve stocks accumulated in previous years. The mica consumed in India is used for ornament and decoration, pictures being painted on some of the larger sheets.

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Of the mica exported from India in 1908 to 1914 about 55 per cent went to the United Kingdom, 17 per cent to the United States, 16 per cent to Germany, and 8 per cent to Holland.

The open-cut working at Kabbur, Mysore State, has been considerably extended[1] and now is about 400 feet long, 45 feet across, and 38 feet deep. The pegmatite vein exposed at the bottom of the cut seems to be persistent and continuous and contains "books" of mica irregularly distributed through it. Neither the quality nor the quantity of mica has improved with depth, and the net yield of sheet mica is seriously affected by the crushed, ruled, and damaged conditions of the mica books. Up to date about 7 tons of sheet mica of small size has been exported.

[1] Mysore State Dept. Mines and Geology Records, vol. 14, pt. 2, p. 178, 1916.

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FLUORSPAR AND CRYOLITE.

By Ernest F. Burchard.[1]

FLUORSPAR.

INTRODUCTION.

Fluorspar is one of the nonmetallic minerals of moderate intrinsic value the demand for which has increased greatly since the beginning of the European war on account of its usefulness in the metallurgic, ceramic, and chemical industries, especially in the manufacture of open-hearth steel, enameled sanitary ware, and hydrofluoric acid. A discussion of the character and occurrence of fluorspar, its preparation and uses, the industry preceding and during the war, and the available supplies has therefore been prepared as a separate publication,[2] which may be obtained upon application to the Director of the United States Geological Survey, Washington, D. C.

Noteworthy features of the fluorspar industry in 1916 were the continued strong demand and increased prices, which culminated at the end of the year in a shortage of spar that forced prices for prompt shipments to an unprecedented level. The increased interest that has been manifested in fluorspar by manufacturers and miners during the last three years has resulted in a search for new deposits especially in the Western States, and several discoveries have been reported to the United States Geological Survey, but there has been little commercial production from such deposits. In southern Illinois and western Kentucky some prospects have been reopened under the stimulus of higher prices, and such deposits bid fair to contribute to the production in 1917.

The year 1916 was a record year for production of fluorspar in the United States, the next highest year having been 1915.

Early in 1917 interest was awakened by the Geological Survey in behalf of the United States Naval Consulting Board to the possibility of developing a domestic supply of fluorspar for use in optical instruments. Fluorspar has low refractive and dispersive powers and is especially adapted for use in apochromatic lenses, such as are used in telescopes and spectroscopes. Fluorspar suitable for optical instruments must be glass clear and free from clouds, gas bubbles, strains, flaws, and fractures, but a faint color is not altogether objectionable. Some absolutely clear fluorspar has been imported

[1] The statistics in this chapter were compiled by Miss L. M. Jones, of the United States Geological Survey.

[2] Burchard, E. F., Our mineral supplies—Fluorspar: U. S. Geol. Survey Bull. 666–CC, 1917.

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from Japan and has been valued at about $30 an ounce, it is reported. Very little, however, has been produced commercially in the United States, and it is very rare and difficult to obtain. In order to ascertain whether suitable material is contained in lumps of fluorspar it is necessary in the laboratory to slice off pieces along the cleavage planes. Very small pieces will suffice; for example, lenses now in use contain pieces of fluorspar 2 millimeters to 3 millimeters in thickness and 5 millimeters to 10 millimeters in diameter. As a result of requests by the Geological Survey to the fluorspar producers of the United States to watch carefully for any crystals that may appear exceptionally clear and free from flaws several promising samples have been received in Washington, and as a result of tests by the Bureau of Standards a few have been found to be of value. One of these pieces was found near Elizabethtown, Ill., and another in Crittenden County, Ky.

Even though the value of this grade of spar may be high, the time required to search for it is in most cases worth still more, and for this reason the Geological Survey desires to express its appreciation of the patriotic efforts that have been made by fluorspar producers to furnish material of optical grade in order that the United States may be independent of foreign sources of supply in time of war.

DOMESTIC OUTPUT.

The total quantity of domestic fluorspar reported to the Survey as sold in 1916 was 155,735 short tons, valued at $922,654, an increase in quantity of 18,794 short tons and in value of $158,179, representing nearly 14 per cent of the quantity and nearly 21 per cent of the value of the product marketed in 1915. The average price per ton for the whole country, all grades of fluorspar, gravel, lump, and ground considered, was approximately $5.92 in 1916, compared with $5.58 in 1915, an increase of about 6 per cent. This value represents the selling price on board cars or barges at railroad or water shipping points. In Colorado, New Mexico, and New Hampshire the price reported for much of the spar includes the cost of a long wagon haul—$1.50 to $3 a ton. In Illinois the principal producing mines are near river transportation, and many of the mines reporting from Kentucky are near a railroad, so that the cost of long wagon hauls has not entered to an important extent into the reported value of the fluorspar from those States.

As usual, the bulk of the fluorspar sold was in the form of gravel spar, the quantity in 1916 amounting to 133,651 short tons, or nearly 86 per cent of the total. Two grades of spar, gravel and lump, showed important increases in 1916 over all preceding years, but ground spar did not show as large an output as in 1915, the decrease in quantity having been more than 29 per cent in 1916. The general average price of domestic fluorspar declined steadily from 1912 to 1915, largely as a result of improvements in methods of milling and handling large quantities of spar in the Illinois-Kentucky district, and this price was lower in 1915 than at any time in the last 10 years; but in 1916, as predicted in this chapter in Mineral Resources for 1915, an increase in price was to be expected. The average price of all grades of spar increased in 1916, the ground spar $1.58 and the gravel and lump 45 and 43 cents per ton, respectively.

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Early in 1917 consumers who had not contracted in advance for their needs were obliged to pay extraordinary prices for fluorspar. The two following quotations from the the Iron Trade Review serve to show the conditions of supply and demand in the winter of 1917:

Philadelphia, January 9.[1]—Gravel fluorspar for prompt shipment continues exceedingly scarce and prices now are quoted at $21.50 per ton at the mines. This compares with a price of $7, at which many of the steel companies have closed contracts for their 1917 requirements. Lump fluorspar is held at about the same figure as gravel. The mines have their output sold up practically through 1917, especially on gravel.

Philadelphia, February 6.[2]—Fluorspar for prompt shipment continues to command very high prices. A sale of a number of cars of gravel spar for delivery by April has been made to a steelworks buyer in this district at $21.50 at the mines.

Shipments (or sales) of fluorspar were reported from five States in 1916—Illinois, Kentucky, Colorado, New Hampshire, and Arizona, in the order named. All these States showed increase in quantity sold in 1916, Arizona having reported no sales in 1915. New Mexico, which reported a small output in 1915, reported none for 1916. An operator near Keller, Ferry County, Wash., reports having mined but not shipped a small output of fluorspar in 1916.

In Illinois the output in 1916 came from 2 mines in Hardin County; in Kentucky 16 operators shipped spar—14 in Crittenden County, 1 in Caldwell County and 1 in Livingston County, but the actual number of mines is uncertain, as much of the output is purchased by two firms from small workings—and 1 mine in New Hampshire, 1 in Colorado, and 2 in Arizona shipped fluorspar during the year.

The total quantity of crude fluorspar reported to the Survey as mined in the United States in 1916 was 175,165 short tons compared with 136,277 short tons mined in 1915, an increase of more than 28 per cent.

The total stocks of fluorspar reported at mines or at shipping points December 31, 1916, were 3,666 short tons compared with 8,497 short tons on hand at the end of 1915. The stocks in 1916 consisted of 3,351 short tons of gravel spar, 165 tons of lump spar, and 150 tons of ground spar. Stock on hand is for the most part only roughly estimated by producers, and therefore these figures can be regarded as only approximate. It is not to be expected that the stocks at the end of one year, plus the quantity mined the next year, minus the quantity sold will check with the stocks on hand at the end of the second year, because the quantity mined is crude spar and the quantity sold, as well as most of the stocks, is of clean or milled spar and there is considerable loss in milling.

The output of fluorspar in 1916 doubtless would have been greater had not the mines in southern Illinois been shut down for part of July on account of miners' strikes. For a time the outlook for consumers threatened to become serious, as the southern Illinois district customarily produces 75 to 80 per cent of the domestic output.

Such details of the fluorspar sales as may be published by the Survey without revealing statistics of individual producers are given in the following table for the years 1913 to 1916. Of these years the last three were "war" years, 1914 showing decidedly subnormal conditions and 1915 and 1916 possibly abnormal conditions.

[1] Iron Trade Rev., Jan. 11, 1917, p. 129. [2] Idem, Feb. 8, 1917, p. 356.

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Domestic fluorspar sold, 1913–1916.

State.	Gravel.			Lump.			Ground.			Total.		
	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.
1913.												
Illinois	91,663	$525,456	$5.73	5,676	$39,059	$6.88	8,137	$100,203	$12.31	85,854	$550,815	$6.42
Kentucky										19,622	113,903	5.80
Other States [a]	[b] 10,104	71,568	7.08	(b)	(b)					10,104	71,568	7.08
	[b] 101,767	597,024	5.87	[b] 5,676	39,059	6.88	8,137	100,203	12.31	115,580	736,286	6.37
1914.												
Illinois	77,048	397,913	5.16	8,842	74,708	8.45	6,998	82,428	11.78	73,811	426,063	5.77
Kentucky										19,077	128,986	6.76
Other States [a]	[b] 2,228	14,992	6.73	(b)	(b)					2,228	14,992	6.73
	[b] 79,276	412,905	5.21	[b] 8,842	74,708	8.45	6,998	82,428	11.78	95,116	570,041	5.99
1915.												
Illinois	112,769	547,415	4.85	12,033	90,337	7.51	10,757	116,161	10.80	135,559	753,913	5.56
Kentucky												
Other States [a]	[b] 1,382	10,562	7.64	(b)	(b)					1,382	10,562	7.64
	[b] 114,151	557,977	4.89	[b] 12,033	90,337	7.51	10,757	116,161	10.80	136,941	764,475	5.58
1916.												
Illinois	123,983	660,714	5.33	14,489	114,993	7.94	7,595	94,039	12.38	146,067	869,746	5.95
Kentucky												
Other States [a]	[b] 9,668	52,908	5.47	(b)	(b)					9,668	52,908	5.47
	[b] 133,651	713,622	5.34	14,489	114,993	7.94	7,595	94,039	12.38	155,735	922,654	5.92

[a] Includes, 1913: Arizona, Colorado, New Hampshire, and New Mexico; 1914: Colorado and New Hampshire; 1915: Colorado, New Hampshire, and New Mexico; 1916: Arizona, Colorado, and New Hampshire.

[b] Some lump spar is included with gravel.

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In the following table summarizing the annual output of domestic fluorspar from 1883 to 1916, the quantities from 1883 to 1905 represent quantity mined; beginning with 1906 they represent quantity sold.

Fluorspar output in the United States, 1883–1916.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1883	4,000	$20,000	1895	4,000	$24,000	1907	49,486	$287,342
1884	4,000	20,000	1896	6,500	52,000	1908	38,785	225,998
1885	5,000	22,500	1897	5,062	37,159	1909	50,742	291,747
1886	5,000	22,000	1898	7,675	63,050	1910	69,427	430,196
1887	5,000	20,000	1899	15,900	96,650	1911	87,048	611,447
1888	6,000	30,000	1900	18,450	94,500	1912	116,545	769,163
1889	9,500	45,835	1901	19,586	113,803	1913	115,580	736,286
1890	8,250	55,328	1902	48,018	271,832	1914	95,116	570,041
1891	10,044	78,330	1903	42,523	213,617	1915	136,941	764,475
1892	12,250	89,000	1904	36,452	234,755	1916	155,735	922,654
1893	12,400	84,000	1905	57,385	362,488			
1894	7,500	47,500	1906	40,796	244,025		1,306,696	7,949,721

Figure 8 shows graphically the course of the production of fluorspar in the United States from 1883 to 1916. Two periods of fluctuation in output—between 1889 and 1897 and between 1902 and 1908—are in strong contrast with the large and steady increase in production in the periods 1897 to 1902 and 1908 to 1912. The decline from 1912 to 1914, although the greatest in actual tons, is not so great in proportion to the current production as that from 1905 to 1906, and the increase from 1914 to 1916 is clearly the largest in any similar period. For convenience of comparison the imports, beginning with the first full year for which records are available, 1910, are shown on the same diagram.

IMPORTS.

The imports of fluorspar into the United States entered for consumption in 1916 were 12,323 short tons, valued at $54,000, compared with 7,167 short tons, valued at $22,878, in 1915. This represents an increase of about 72 per cent in quantity and of 136 per cent in value. The price assigned to the imports in 1916 averaged $4.38 a ton, as compared with $3.19 a ton in 1915, an increase of $1.19 a ton, or about 37 per cent. The imports of fluorspar in 1916 were equivalent to about 9.2 per cent of the domestic production of gravel spar, as compared with nearly 6.3 per cent in 1915. The average reported price of imported spar at dock, exclusive of the duty, was equivalent to about 82 per cent of the average price of domestic gravel spar at mines or nearest shipping points in 1916, compared with 65 per cent in 1915. According to the prices reported, including the duty of $1.50 a ton but excluding freight charges, the average cost of imported spar to the consumer was $5.88 a ton in 1916, compared with $5.34 for domestic gravel spar at the mines or mills; in 1915 the cost of the imported material, including the duty of $1.50 a ton, was $4.69, compared with $4.89 for domestic gravel spar. The freight charges on domestic spar to points where it is consumed are gen-

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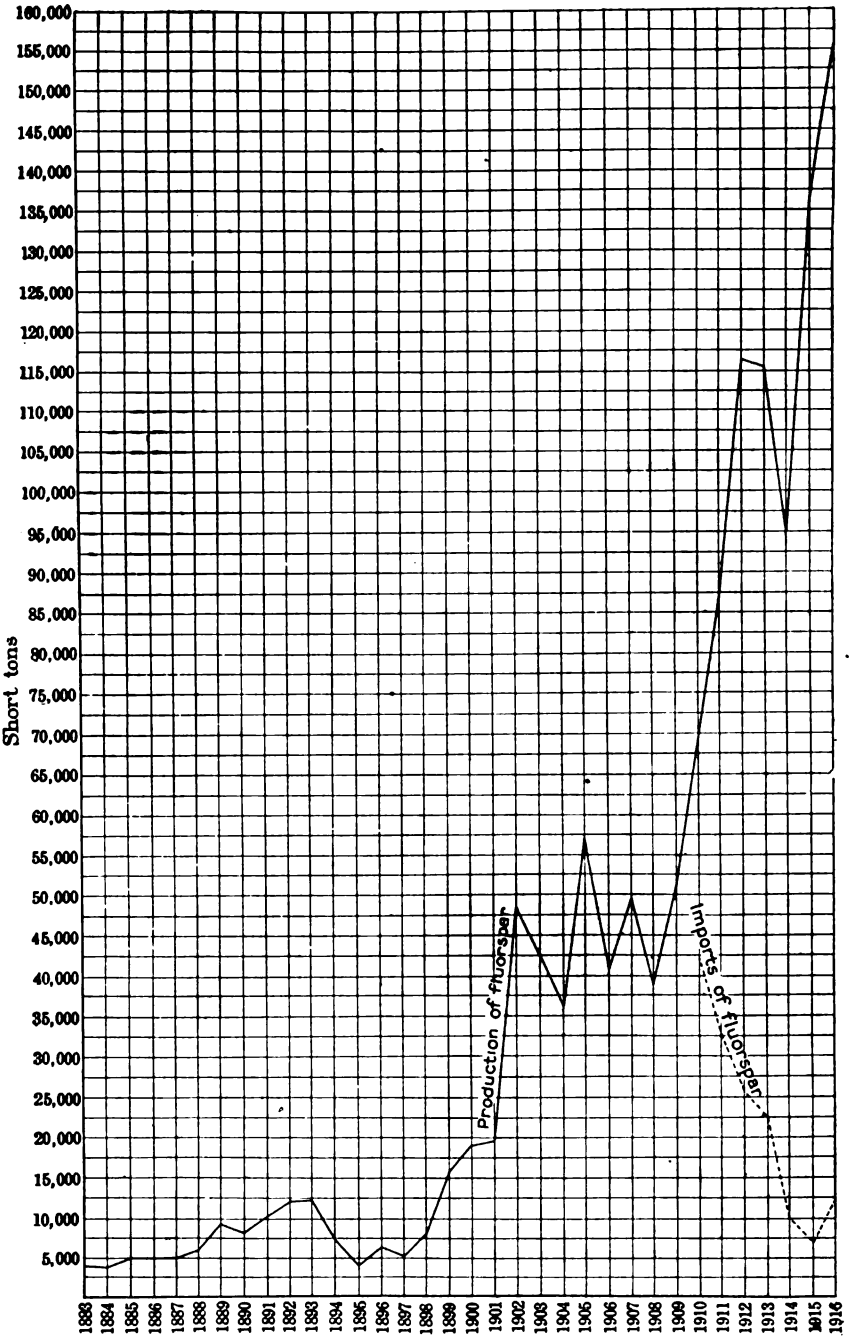

FIGURE 8.—Production of fluorspar in the United States, 1883–1916, and imports, 1910–1916.

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erally higher than on foreign spar from the docks to eastern steel plants, so that a slight advantage in price still may be enjoyed by the imported spar at eastern steel plants. Foreign spar is, however, not generally of so high grade as the mechanically treated spar from Illinois and Kentucky, and since fluorspar is of value chiefly according to its purity, purchasers should find that the purer American spar is more efficient and consequently cheaper in the end. Recently difficulties in getting supplies of fluorspar from American mines when needed, on account of freight embargoes, lack of cars, difficulties of transportation on Ohio River, and labor troubles, have led steel manufacturers to accept readily whatever foreign spar was available.

Fluorspar imported and entered for consumption, 1909–1916.[a]

	Quantity (short tons).	Value.	Average price per ton.
1909	6,971	$26,377	$3.78
1910	42,488	135,152	3.18
1911	32,764	80,592	2.46
1912	26,176	71,616	2.74
1913	22,642	71,463	3.15
1914	10,205	38,943	3.82
1915	7,167	22,878	3.19
1916	12,323	54,000	4.38

[a] Statistics compiled from records of Bureau of Foreign and Domestic Commerce, Department of Commerce.

CONSUMPTION.

The market for the bulk of the fluorspar sold in the United States depends on the steel industry and the demand fluctuates with the rise and fall in the production of steel. Gravel spar is consumed as a flux in basic open-hearth steel furnaces and to a smaller extent in other metallurgical operations. In both 1914 and 1915 the sales of gravel spar constituted between 83 and 84 per cent of the total marketed output of domestic fluorspar, and in 1916 it was nearly 86 per cent. Fluorspar is used also as a flux in iron blast furnaces, iron foundries, and in gold, silver, copper, and lead smelters; in the manufacture of fluorides of iron and manganese for steel fluxing and of sodium fluoride for wood preservation;[1] in the manufacture of glass, enameled, and sanitary ware, and of hydrofluoric acid; in the electrolytic refining of antimony and lead; and in the production of aluminum. Other miscellaneous uses of fluorspar that have been reported are as a bonding for constituents of emery wheels, for carbon electrodes, in the extraction of potash from feldspar, and in the recovery of potash in Portland cement manufacture. The last use depends on the suitability of calcium fluoride as a reagent for increasing the volatilization of potassium salts from the clinker and the regeneration of the reagent from the dust collected.[2]

[1] Teesdale, C. H., Use of fluorides in wood preservation: Wood Preserving, vol. 3, No. 4; vol. 4, No. 1. (Reprint, 9 pp.)

[2] Treanor, John, Potash from cement at the Riverside Portland Cement Co.: Met. and Chem. Eng., June 15, 1917, pp. 701–703.

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The recovery of potassium compounds from flue dust of cement works is noted in mention of United States patent 1219315, as follows:[1]

Cement-works flue dust is calcined with CaF_2, and a second flue dust thus formed is collected and treated with H_2O and CaO or $CaSO_4$ to recover the F and soluble K compounds which it contains.

A close estimate of the annual consumption of fluorspar in the United States can not be made without a knowledge of the stocks maintained by the consumers. These stocks are probably variable and are low at present (August, 1917), but, as the value of fluorspar as a flux in the manufacture of open-hearth steel and in other metallurgical operations has become generally appreciated, consumers have made efforts to keep stocks in reserve. However, the sales of domestic spar plus the imports (there are no considerable exports at present, and the figures are not listed separately by the Bureau of Foreign and Domestic Commerce) should give from year to year an index to the quantity entering into consumption and should indicate the relative increase or decrease in consumption. The apparent consumption of spar in 1916 was 168,058 short tons, as compared with 144,108 short tons in 1915, an increase of nearly 17 per cent.

The general relation between the consumption of fluorspar and the output of open-hearth steel may be noted by comparison of the following two tables:

Apparent consumption of fluorspar, 1910–1916, in short tons.

	Sales of domestic spar.	Imports for consumption.	Apparent consumption.
1910	69,427	42,488	111,915
1911	87,048	32,764	119,812
1912	116,545	26,176	142,721
1913	115,580	22,682	138,262
1914	95,116	10,205	105,321
1915	136,941	7,167	144,108
1916	155,735	12,323	168,058

Open-hearth steel produced in 1910–1916, in long tons.[a]

	Basic.	Acid.	Total.
1910	15,292,329	1,212,180	16,504,509
1911	14,685,932	912,718	15,598,650
1912	19,641,502	1,139,221	20,780,723
1913	20,344,626	1,255,305	21,599,931
1914	16,271,129	903,555	17,174,684
1915	22,308,725	1,370,377	23,679,102
1916	29,616,658	1,798,769	31,415,427

[a] Statistics for 1910 and 1911 according to annual reports of the American Iron and Steel Association and since 1911 from report of American Iron and Steel Institute.

FLUORSPAR PRODUCTION OF CANADA, 1916.[2]

Shipments of fluorspar were made from Madoc, Ontario, during 1916 amounting to 1,284 tons, valued at $10,238, or about $7.97 a

[1] Chem. Abstracts, vol. 11, p. 1535, 1917.
[2] Preliminary report of the mineral production of Canada during the calendar year 1916, Canada Dept. Mines, Mines Branch.

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ton. This was practically the first commercial operation of these deposits.

FLUORSPAR IN GREAT BRITAIN.

According to the official report[1] of output of mines and quarries issued by the Home Office at London, there were produced in Great Britain in 1915, the latest year for which statistics are available, 33,123 long tons of fluorspar, valued at $55,887, or $1.69 a ton, compared with 33,816 long tons, valued at 53,556, or $1.58 a ton, in 1914. The statistics for 1914 and 1915 are not given in the same detail as those for former years, which showed the output from mines and from quarries from both Derbyshire and Durham. When the output of fluorspar in England in 1911 to 1915 is compared with the imports of fluorspar into the United States in those years, and when it is considered that the imports are derived almost wholly from England, it appears that the proportion of the production of England that was shipped to the United States during those years steadily decreased. The percentage in 1915 was about 19, as compared with about 27 per cent in 1914, 37 per cent in 1913, 49 per cent in 1912, and 53 per cent in 1911.

Authentic information concerning the fluorspar resources of Great Britain has of recent years not been readily available, therefore a special report on fluorspar[2] issued by the Geological Survey of Great Britain in 1916 is most welcome and interesting. This report, which is brief, consists of a preface and three chapters. The first chapter treats of the chemical composition, physical properties, sources of supply, uses, and statistics of fluorspar; the second contains a description of mines in Durham, Northumberland, Yorkshire, and Cumberland; and the third a description of the mines in Derbyshire, Cornwall, and North Wales.

The preface contains the following interesting statement:

> Fluorspar * * * occurs in abundance in the lead and zinc veins of Derbyshire and Durham, and in smaller quantities elsewhere. It is commonly associated with calc-spar, quartz, and barytes in the gangue of the veins, but it is noticeable that in Derbyshire, where the country rock is chiefly limestone, the association is with calc-spar and barytes, though in Durham, where much of the country rock is arenaceous, the association is with calc-spar and quartz.
>
> The output has been for many years in excess of home requirements and much fluorspar has been exported. In Derbyshire the spar has been obtained at small cost by turning over the great heaps of material thrown aside by the old miners as useless, but this source is approaching exhaustion and recourse is being had to the more costly process of mining. In Durham the veins, which were left intact by the old miners except in those parts which contained galena in paying quantity, have been the chief source of the local supply for about 20 years.

As to sources of supply it is stated:

> Although some thousands of tons of fluorspar are annually raised in France and Germany (Bavaria and Saxony), and a little also in Spain, the bulk of the world's supply comes from Britain and the United States, the latter being also the chief consumer.
>
> In Britain neither Scotland nor Ireland need be considered, but in England and Wales there are four centers—(1) Derbyshire, (2) the north of England

[1] Mines and quarries, general report for 1915, pt. 3, p. 113, 1916.

[2] Carruthers, R. G., Pocock, R. W., Wray, D. A., with contributions by Dewey, H., and Bromehead, C. E. N., Fluorspar: Special reports on the mineral resources of Great Britain, vol. 4 (Geol. Survey Mem.), 38 pp., 1916.

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(Durham), (3) Cornwall, (4) North Wales (Flintshire); of these only the first two are of importance. In Cornwall the fluorspar is associated with ores of both copper and lead. It traverses granite and lower Paleozoic rocks, and is frequently pale green or yellow in color, in contrast with other districts, where amethystine tints prevail. In Derby, Durham, and Flintshire the fluorspar occurs in the gangue of galena and blende veins, traversing Carboniferous limestone strata; in Durham, however, sandstone and shale predominate over limestone.

In Derbyshire the fluorspar is associated with barytes, and quartz is absent, but in Durham the converse holds. In both fields large bodies of clean spar can be got, but in Flintshire the fluorspar is intimately mixed with other minerals.

The following statement is given concerning the fluorspar deposits in the various counties:

Durham.—Although fluorspar is of frequent occurrence amongst the metalliferous veins of the north of England, yet the commercially productive area is restricted, and at the present time the whole supply comes from the upper part of Weardale.

Upper Weardale, from Stanhope up to the western watershed, covers 80 or 90 square miles. All this ground is occupied by Carboniferous strata, mostly belonging to the Yoredale division of the Carboniferous limestone series; on the highest ground there is a capping of Millstone grit. These Yoredale rocks are composed of numerous alternations of sandstone, shale, and limestone, in beds up to 100 feet thick. The dip is gentle, and the outcrops wind in and out of the valleys with much regularity.

The district is an ancient lead-mining center, and that industry is still carried on, although by no means on the scale of past times. The working of fluorspar is a comparatively new feature, having been started in earnest less than 20 years ago.[1]

The veins are abundant and are of the normal fissure type, mostly filling small faults. They are orientated in two groups, one trending southwest, the other between east and southeast. When traversing beds of limestone they frequently give off horizontal stringers or "flats" similar in contents to the veins themselves.

In this district fluorspar is the chief constituent of veins and "flats" alike; sometimes it fills the whole vein, and spar bodies, measuring as much as 20 feet across, have been met with. Galena, although often scattered in small quantities through the spar, is generally concentrated in the center of the vein. Some of the veins carry chalybite instead of galena; in such cases one often finds that it is the fluor which occupies the center of the vein, the iron minerals being in the walls and impregnating the country rock.

Weardale fluor is generally pale colored, an amethyst tint being the rule, although white or clear varieties are also common; green or yellow spar is rare, and red quite absent. The fluorspar is well crystallized and rarely granular. Exceptionally, the crystals are of large size, and in one notable exhibit in the Museum of Practical Geology the cubes measure 6 inches along their edges.

The commonest accessory mineral is quartz. It is found in relatively small quantities, often lining geodes or cavities.[2] Isolated crystals of galena and chalybite are not uncommon, although, as mentioned previously, these are usually concentrated in the center of the vein. Pyrites is rare, and in contrast with the Derbyshire and Kentucky deposits there is an entire absence of barytes. The only other accessory mineral of any importance is calcite, which is never abundant and in most of the veins is quite a rarity.

While most of the veins can be depended on to carry fluorspar steadily for long distances (in some cases several miles), nevertheless they are subject occa-

[1] The first record, for Durham, in the Home Office "Returns of mines," etc., was in 1883, when the Weardale Iron & Coal Co. (Ltd.) produced 13 tons of spar from the Red vein (probably the Crawley mine). The next year that company raised 109 tons, and less in subsequent years until 1898, from which date the output increased rapidly.

[2] The mode of occurrence suggests that the presence of quartz has depended upon the character of the country rock. Quartz is not associated with the fluorspar in that part of Derbyshire where the country rock is limestone, with relatively small amounts of chert or other siliceous matter, but appears near Bonsall and Castleton, where the limestone has been silicified. In Weardale the veins traverse strata some 50 per cent of which is arenaceous.

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sionally to abrupt changes. A case in point is the Slit vein on Peat Hill, above Eastgate. Here, on the east side of the hill road, there occurs an extensive opencast working for ironstone. The vein, with its branches, is full of iron ore, which has also deeply impregnated the shattered limestone alongside; no trace of fluorspar can be seen. Only 300 yards to the southeast the vein can be picked up again in a small limestone quarry; the ironstone has all gone, the limestone walls are clean, and the vein is filled with pure crystalline fluorspar. A similar change is also reported to take place under the floor of the opencast; and, in confirmation of this, fluorspar is abundant in the waste heaps on the valley bottom to the west.

The effects of depth have not yet been fully tested in Weardale, no necessity having arisen to seek the spar at a depth where haulage and pumping charges must increase. The deepest working is probably at Sedling, where, at a depth of 64 fathoms, no deterioration in the spar bodies has been noticed, but probably the veins will eventually be found to dwindle in depth as they do both in Derbyshire and Kentucky.

Variations in the type of country rock have not been shown to affect the quality of the spar, but as regards quantity, while it is undoubtedly true that the largest bodies generally occur in the limestones, nevertheless sandstone strata often yield well. In that respect a contrast is afforded with the Kentucky deposits, where much brecciation and poor yields are the rule at sandstone levels. Shale (or "plate") generally has an adverse effect.

Most of the spar is exported to America and Russia for steel smelting. The demand for other purposes seems to be quite small. Most of the spar is sent away in either "lump" or "gravel" form. Any grinding done is carried out to extract galena, rather than to produce fluor "sands," for which there is little demand as far as Weardale is concerned.

In contrast with Derbyshire, little fluor has ever been got by picking over old surface dumps, and at the present time none is so obtained. At one or two mines the vein worked has not been opened before, but, as a rule, access to the spar is greatly facilitated by the work of the old lead miners, who have "slit" the veins—that is, cut out the central part, where the galena was concentrated—and have also stowed their "gob," or waste, with such fluorspar as they were compelled to remove in their search for lead. Their adits have also unwatered large tracts of ground which can still be worked for fluorspar.

For even an approximate estimate of reserves abundant data on the rapid variations in the veins would be necessary, but the number of still untouched veins and the relatively small amount of work done on the others create a strong impression that the industry is still in its infancy and that the present output could be greatly increased without danger of exhaustion for a prolonged term of years.

At the present time there are three centers for fluor production in Upper Weardale. These are (1) St. John's Chapel, (2) Rookhope, (3) Stanhope.

Northumberland.—Fluorspar is an abundant constituent of the gangue in the old galena mines around Allenheads, a few miles north of the Upper Weardale watershed. Apparently it has never been specially mined there, but there are large quantities on the waste heaps at the mine heads. About 1910 Messrs. George Blackwell, Sons & Co. had several of these waste heaps hand picked for "lump" spar, and many thousand tons were taken away, but a much greater amount still remains untouched. The spar is mostly in small blue "lump" and "gravel," and is hard and clear. It was used for fluxing purposes.

Certain layers in these waste heaps consist almost wholly of fluor "gravel," evidently taken out when the vein was broad; the upper layers of the heaps, representing the material last thrown out of the mine, usually consist of "plate" and country rock, possibly indicating that the veins "pinch out" in depth.

The transport of the spar was by a good but hilly road, 4 miles to Wearhead station (Northeast Railway), and it is this consideration which has, in the meantime, stopped any spar working in the Allenheads district.

Yorkshire.—In the higher parts of Swaledale and Wensleydale some of the veins occasionally carry fluorspar, but nowhere in workable quantity. The spar occurs as nests in the lead veins at Old Rake and South Arngill mines, near Muker, where they traverse the Carboniferous limestone. It has been observed also in the Friarfold mine, near Surrender, and in an east and west fault which follows the course of a fault at Marble Scar, near Gunnerside. It is usually of a purple shade.

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In Upper Wensleydale small quantities of yellow fluorspar have been observed at Mossdale Gill.

Cumberland.—Rotherhope mine, Alston. * * * The Rotherhope Fell vein, worked from this mine, is a fissure vein trending southwest. It is unusually broad, averaging 15 feet, with a maximum of 30 feet, but much of this consists of shattered country rock, set in a matrix of fluorspar, quartz, and calcite, with galena and a little blende. On the northwest flank of Rotherhope Fell the vein is traceable for at least 2 miles, and to the northeast runs across the South Tyne River to join the Dowpot vein. The fluor is of good quality, but is closely intergrown with the other minerals, so that pure lump is an exception. The best level for spar is at the Whin Sill, here found under the Single Post limestone; the Scar limestone is also a good producer.

The main adit, opposite Blackburn Bank, is driven 1,200 yards in a southeast direction, to cut the vein; only 1,500 yards have been proved so far, the intersecting Sir John's vein, to the northeast, not having yet been reached. The water is not in serious amount—40 gallons per minute in the lower sills, but not more than half that amount as an average for the whole mine.

After washing, a small amount of lump spar is got by hand picking, but by far the greater quantity of fluorspar is produced as a "gravel" residue from the galena pigs, after crushing. It is not salable at present, but has been used for fluxing purposes. Alston station (Northeastern Railway) is 3 miles distant by road. This mine is only now being developed. As noted above, it is primarily a galena mine, and most of the fluorspar produced is in the form of a fine "gravel" residue from the ore jigs. It is impossible to effect complete separation of the small quantities of quartz, calcite, and blende present in the spar.

Derbyshire.—In Derbyshire, the oldest and best known center in Britain for the production of fluorspar, the mineral is found in filling vein fissures and other cavities in the Carboniferous limestone. These deposits have received much attention, and have been investigated of late years by Messrs. Wedd and Drabble,[1] the result of whose work has been largely utilized in the following introductory remarks.

The limestone is visible in Derbyshire to a thickness of at least 1,700 feet, and the base is never reached. The arrangement is that of a broad anticline, the western margin of which is much the more steeply inclined. Southeastward of the main mass two prominent inliers of limestone (Crich and Ashover) project through the enveloping ring of shales and grits. Several igneous sheets, both contemporaneous and intrusive, are known in the upper half of the limestone, and the uppermost limestones are abundantly fossiliferous; lower down the limestone contains few fossils and is to some extent dolomitic.

Mineral deposits in Derbyshire are classified as follows: (*a*) Rakes or rake veins—deposits in enlarged joints, faults, fissures, or cracks. In the last-named case they are known as "scrins." (*b*) Pockets—deposits in chambers on the side of a rake. (*c*) Pipes—the combination of joint or fissure cavities with one or more horizontal cavities formed along the bedding, the whole being more or less completely filled with mineral matter. (*d*) Flats—deposits in horizontal cavities formed along the bedding and regarded independently of "pipes."

Rake veins are the commonest type; they traverse the limestone massif everywhere, but are particularly abundant in its eastern half. The majority can be arranged in two groups, the first running west or west by south and containing the most persistent veins, some being traceable for nearly 7 miles; the other group, trending southeast, attains a maximum around Matlock, but the veins, though abundant, are relatively short.

Fluorspar is found in comparatively few of these veins. According to Messrs. Wedd and Drabble it is practically confined to the limestone and does not pass up into the overlying grits and shales; also it is restricted to the uppermost 600 feet of the limestone, and is mainly concentrated in the uppermost 300 or 400 feet. The effect of this restriction is to confine the occurrences to the margin of the limestone massif; inwards from the margin or in depth the spar is replaced by barytes and calcite. They noticed, further, that practically all the fluor comes from the eastern margin of the massif, and from the Crich and Ashover inliers beyond; little is found along the western fringe.

[1] Wedd, C. B., and Drabble, G. C., The fluorspar deposits of Derbyshire: Inst. Min. Eng. Trans., vol. 34, pp. 501–535, 1908.

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The massive commercial fluorspar of Derbyshire is usually opaque white or but faintly tinted; the well-grown cubes found in cavities are more highly colored, ranging from amber-yellow to deep violet. Green, pink, and pure blue tints are noticeably absent, although "ruby-colored fluor in perfect cubes" has been recorded. A variety peculiar to the county is known at "blue John"; it is strictly local in occurrence and is used solely for ornamental work.

The spar is associated with barytes, calcite, and galena; sometimes with blende also, but only locally with copper ores. The metallic minerals are often concentrated in the center of the vein. The rarity of quartz is a noteworthy feature.

Most of the fluorspar, both "lump" and "gravel," is devoted to fluxing in iron and steel founderies. Fluorspar from Ashover is said to be in demand for refining silver and gold.

The "fine-ground" spar is used for making hydrofluoric acid; the finest quality makes a pure-white enamel glaze for pottery, especially for lavatory ware, this demand being specially catered for at Stubbin Low or Smith's mine, near Bonsall.

Derbyshire fluorspar is usually put on the market in two grades, viz, "lump spar," as the spar got direct from the mines is termed, and "gravel spar." The latter consists of the tailings from the old ore dressings, and contains from 55 to 75 per cent of calcium fluoride. These tailings are screened from the old "hillocks." The "lump spar" has in general some impurities in the shape of calcite, barytes, etc., and when dressed for market averages from 90 to 95 per cent of calcium fluoride, anything above 95 per cent being exceptional.

Near Matlock and at Ashover a third grade of spar is now being produced, viz, fine-ground fluorspar. For this grade good "lump spar" is ground in a ball mill.

All the mines were originally worked for lead. The fluorspar was merely a by-product of no commercial value, but its increasing use in smelting, etc., has been the main cause for the reopening of certain mines, in some of which much fluorspar is stored in the "gob" of the old workings.

Under present conditions, when both the fluorspar and the lead can be marketed, and when also the price of lead has advanced considerably from its previously low level, the prospect for the profitable working of the Derbyshire mines has greatly improved.

The available supply of fluorspar is regarded by Messrs. Wedd and Drabble as almost intact and capable of bearing the strain of a greatly increased annual output for a great number of years.[1] It must be added, however, that the surface waste heaps which have been the mainstay of the Derbyshire output for the last six years have now been well picked over and are no longer of serious account for future supplies.

Cornwall.—No fluorspar is being raised in Cornwall, but the mineral is recognized sparingly in the mining parts of the county in association mainly with copper ores.[2] The copper ore as a rule is replaced in depth by tin ore and wolfram, and the fluorspar usually dies out in a similar manner. An unusual occurrence is that of a pocket of fluorspar with redruthite at 190 fathoms depth in Tincroft mine, Illogan. The important copper lodes are for the most part worked out, and the mines abandoned, but fluorspar may be found on many old dumps and near the towns as, for instance, round Redruth it has been picked out and sold to local assayers. In recent years all mines have taken to making wet assays for themselves, and there is, therefore, no sale for small parcels of fluorspar.

At one mine only has any appreciable amount of fluorspar been obtained in recent years. On Hingston Downs, near Gunnislake, a vein of fluorspar 20 feet wide was struck in 1906. This mine is not now working, but would yield tin and wolfram with fluorspar as a by-product under favorable circumstances.

North Wales (Flintshire).—Fluorspar occasionally accompanies the ores of lead and zinc in the veins which traverse the Carboniferous limestone and Mill-

[1] Op. cit., p. 30.

[2] According to Rudler, fluorspar is a notable accessory in the lead veins also, especially those near Liskeard. Handbook to the collection of minerals of the British Isles: Geol. Survey Mem., p. 86, 1905.

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stone grit of Flintshire, but nowhere in sufficient quantity or purity to repay extraction.

The Bryngwiog lode at the Halkyn mine yields a zinc blende, which, after concentration, contains as much as 10 per cent of fluorspar, but would not repay mining for that spar. The Rhosesmor veins, some east and west veins at Pen-y-bryn, and the Coed Cymric vein, about 2 miles southwest of Mold, all contain some fluorspar, but not in paying quantity.

In all these cases it is possible that some special method of separation, such as the Ilmore flotation process, might be successful, but no attempts appear to have been made.

Each mine description given in the text states the exact location of the mine, refers to the availabe maps of the locality, and contains valuable notes bearing on the geologic and mineralogic associations of the ore bodies, but for these details the reader is referred to the report itself.

CRYOLITE.

PRODUCTION.

No cryolite is produced in the United States, the entire supply used in this country being imported from Greenland.

CHARACTER.

Cryolite is a double salt of sodium fluoride and aluminum fluoride ($3NaF.AlF_3$). It crystallizes in the monoclinic system and has a hardness but little greater than that of gypsum, namely, 2.5. It is found associated with other minerals such as siderite, sphalerite, galena, chalcopyrite, and quartz. The color of cryolite is generally pure white, but in places smoke-colored pieces are found which contain well-developed crystals of red fluorspar.

SOURCE.

Cryolite has been found in commercial quantities only at Ivigtut, an Eskimo hamlet on the southern coast of Greenland in latitude 61° N. Minerals containing cryolite have been found near Pikes Peak, Colo., but not in paying quantities. The cryolite deposit at Ivigtut is reported to be a solid mass having surface dimensions of about 200 feet by 600 feet, and it has been worked as an open cut to a depth of about 150 feet. The deposit widens with depth, and the depth is unknown. It is quarried [1] by the Kryolith-Mine og Handelsselskab (the Cryolite Mining & Trading Co., Ltd.) under a State concession.

A recent illustrated article [2] on this deposit contains the following statements:

Cryolite occurs in a small area of porphyritic granite inclosed in older granitic gneiss, as a large irregular mass. Originally at the surface it formed an elongated outcrop about 150 meters long and 30 meters wide, with a northeast-southwest axis. As the deposit was opened it was found to be much larger than the outcrop indicated. It broadened and dipped under the country rock to the east. The boundary in this direction is marked by a pegmatite

[1] Winslow, E. D. (Consul General, Copenhagen, Denmark), Consular Rept., Apr. 9, 1915.
[2] Bernard, C. P., The cryolite mine at Ivigtut, Greenland; Min. Mag. (London), April, 1916, pp. 202–203.

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vein in which a number of rare minerals have been found, including ivigtite and columbite, while cassiterite and molybdenite are also present. The cryolite is of pegmatitic origin. In mining two grades are recognized—the "white" and "black." The "white" contains about 90 to 95 per cent cryolite, the remainder being pyrite, galena, and siderite. The mineral of this grade is shipped to Copenhagen. The "black" contains beside the above impurities a large amount of fluorite. This grade is shipped to Philadelphia and is valued at about $20 per ton.

Mining has been by open cut. Until recently primitive methods were used, but in the last few years dynamite has replaced gunpowder, an air compressor and drills have been installed, and a modern double-drum hoist operates cages in a steel shaftway placed on the side of the open cut.

Production in 1914 amounted to 4,612 tons of "black" cryolite shipped to Philadelphia, and about 12,000 tons of "white" cryolite shipped to Copenhagen. On this production the Government tax amounted to about 550,000 crowns.

Communication during the spring is hazardous, because of the ice. The first ship from Europe usually arrives in April, while the last vessel leaves about the first of November. As a consequence during four or five months of the year the mine is completely isolated. Forty to fifty men are employed the year round, but during the summer this number is increased 50 or 60 brought by the first vessel in the spring. These extra men leave by the last boat in the autumn.

Exploitation of this deposit has been a success from the start, and conservatism in adopting a less cumbersome method of handling ore is largely due to this fact.

USES.

Formerly cryolite was used to produce sodium salts and alum, but other and cheaper sources of these materials are said to have displaced cryolite from this particular field. The more important uses at present for cryolite are in the manufacture of opaque white glass (sometimes called hot-cast porcelain) for the enameling of iron ware, as a solvent for alumina in the manufacture of aluminum, and as a flux in the manufacture of white Portland cement.

IMPORTS AND PRICES.

The quantity of cryolite reported to have been imported for consumption in the United States in 1916 was 3,857 long tons, valued at $165,222, as compared with 3,940 long tons, valued at $82,750, in 1915. The average price per ton declared in 1916 was apparently $42.84, as compared with $21 in 1915. Cryolite is imported free of duty.

The annual imports of cryolite, beginning in 1894, are shown in the following table, according to the records of the Bureau of Foreign and Domestic Commerce. They range from a minimum of 36 long tons in 1910 to 12,756 long tons in 1894, but are mostly between 1,000 and 6,000 tons a year. There are wide variations in average price per ton reported during this period, such as $10.58 in 1898 and $65.08 in 1910. The latter figure may be an error, as there seems to be no especial reason for so high a value in 1910, unless the shipment may have consisted of the white grade of cryolite. In 1916, in keeping with the increased prices of most mineral products due to the demands of war and especially of those dependent upon ocean transportation to centers of consumption, the price rose to $42.84 a ton or more than 100 per cent as compared with that of 1915.

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Cryolite or kryolith imported and entered for consumption in the United States, 1894–1916.

Year.	Quantity (long tons).	Value.	Average price per ton.
1894 [a]	12,756	$170,215	$13.34
1895	8,685	116,273	13.39
1896	7,024	93,198	13.27
1897	3,009	40,056	13.31
1898	10,788	114,178	10.58
1899	5,529	79,455	14.37
1900	5,878	78,658	13.38
1901	6,167	82,533	13.38
1902	4,653	61,116	13.13
1903 [b]	7,708	102,879	13.34
1904	959	13,708	14.29
1905	1,600	22,462	14.05
1906	1,505	29,583	19.66
1907	1,438	28,902	20.10
1908	1,124	16,445	14.63
1909	1,278	18,427	14.42
1910	36	2,343	65.08
1911	2,007	47,093	23.46
1912	2,126	48,203	22.72
1913	2,559	52,557	20.54
1914	4,612	94,424	20.47
1915	3,940	82,750	21.00
1916	3,857	165,222	42.84

[a] Fiscal years, 1894–1902. [b] Calendar years, 1903–1916.

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SAND AND GRAVEL.

By R. W. Stone.

TRADE CONDITIONS.

In 1916 the production of sand and gravel was unprecedentedly large. All kinds of sands increased in total value, and most of them increased in quantity, in spite of the fact that car and labor shortage limited the output of many sand and gravel pits. From many parts of the country it was reported by producers that they could not get enough men to operate at the desired capacity or enough cars to meet their requirements.

In 1915 for the first time a tabulation was made of the condition of the sand and gravel industry as reported in those States having the largest number of producers. Only a small proportion of the thousands of producers of sand and gravel who report annually to the United States Geological Survey answer the question as to their business condition compared with that of the preceding year. Of the 663 producers in six States who reported on the condition of the business in 1915, 281, or 42 per cent, said that the situation was better than in 1914, and 219, or 33 per cent, said it was worse. In 1916 a much larger number replied to this question. In the 838 answers from six States, 54 per cent reported business as better than in 1915, and only 22 per cent reported it worse. A tabulation of these reports on business conditions follows:

Firms reporting condition of sand and gravel industry in 1916 in comparison with 1915.

State.	Better.	Same.	Worse.
Illinois	62	38	24
Indiana	62	30	19
Michigan	92	39	75
New York	55	9	21
Ohio	96	42	19
Pennsylvania	88	36	28
	455	194	189

The tendency toward larger business as shown in this table, the evidence of increased output given in tables on the following pages, and the trend of business in the summer of 1917 indicate that the production of sand and gravel in 1917 will far exceed in quantity and value the production of any previous year.

PRODUCTION.

The tables for 1916 have been prepared by Mrs. L. M. Beach, statistical clerk, from reports received from thousands of producers throughout the United States Were it not for the fact that many producers delay sending in their reports until June or July, this information would be published much earlier in the year.

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Sand and gravel produced in the United States in 1915 and 1916.

1915.

State.	Glass sand.		Molding sand.		Building sand.		Grinding and polishing sand.		Fire or furnace sand.		Engine sand.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons)	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama			169,663	$59,862	157,581	$51,788	(a)	(a)			6,942	$1,779
Arizona					(a)	(a)						
Arkansas	(a)	(a)	(a)	(a)	76,334	33,749						
California	(a)	(a)	48,154	18,393	440,160	140,035	(a)	(a)	(a)	(a)	54,179	6,501
Colorado					(a)	(a)			(a)	(a)	(a)	(a)
Connecticut			(a)	(a)	18,749	4,782	(a)	(a)				
Delaware			(a)	(a)					(a)	(a)		
District of Columbia					(a)	(a)						
Florida					73,916	21,830	(a)	(a)			(a)	(a)
Georgia	(a)	(a)	3,898	2,883	527,258	163,932	(a)	(a)			1,865	390
Hawaii					(a)	(a)						
Idaho												
Illinois	566,128	$299,286	383,185	195,992	1,600,521	472,654	(a)	(a)	(a)	(a)	73,427	14,677
Indiana	(a)	(a)	148,745	36,823	1,620,851	377,343	(a)	(a)	(a)	(a)	153,316	21,989
Iowa	(a)	(a)	(a)	(a)	912,040	262,587			(a)	(a)	30,249	9,353
Kansas					893,937	267,322					66,568	20,388
Kentucky	(a)	(a)	28,815	27,630	413,610	176,792	(a)	(a)	(a)	(a)	7,928	2,896
Louisiana					(a)	(a)					(a)	(a)
Maine					(a)	(a)						
Maryland	(a)	(a)	(a)	(a)	628,460	186,327	(a)	(a)			22,568	19,363
Massachusetts	(a)	(a)	14,196	6,590	377,582	159,997	(a)	(a)	(a)	(a)	(a)	(a)
Michigan	(a)	(a)	82,666	25,998	843,887	236,956	(a)	(a)	(a)	(a)	70,077	2,794
Minnesota			14,150	10,519	319,339	109,119	(a)	(a)			(a)	(a)
Mississippi			(a)	(a)	48,615	16,569					(a)	(a)
Missouri	145,920	91,380	41,284	18,852	794,398	248,225	(a)	(a)	(a)	(a)	67,229	19,970
Montana					6,737	5,825						
Nebraska					572,832	115,356					23,120	4,884
Nevada												
New Hampshire												
New Jersey	(a)	(a)	509,187	331,792	1,838,647	421,927	79,453	$48,236	53,113	$37,184	49,676	20,133
New Mexico					(a)	(a)						
New York			681,129	462,013	3,370,109	788,115	(a)	(a)	(a)	(a)	353,597	108,095
North Carolina					208,398	60,770						
North Dakota					12,750	5,775						
Ohio	128,758	129,528	705,679	503,583	2,251,369	710,139	30,381	29,215	51,882	48,857	66,086	28,263
Oklahoma	(a)	(a)			(a)	(a)					(a)	(a)
Oregon					107,153	69,245					(a)	(a)
Pennsylvania	455,112	550,706	554,809	342,782	2,396,299	931,140	232,731	172,806	82,211	59,134	246,220	139,223

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Rhode Island					(a)	(a)						
South Carolina	(a)	(a)	(a)	(a)	27,881	8,745						
South Dakota					15,333	8,546					(a)	(a)
Tennessee			25,313	11,686	279,892	119,830	(a)	(a)	(a)	(a)	50,848	12,425
Texas			(a)	(a)	356,405	126,437			(a)	(a)	12,113	2,230
Utah					1,556	595	(a)	(a)			(a)	(a)
Vermont			(a)	(a)	(a)	(a)	72,485	22,317				
Virginia	(a)	(a)	36,629	8,645	244,146	86,151	2,440	765	(a)	(a)	46,247	6,881
Washington					197,625	51,471					4,370	2,365
West Virginia	264,076	280,702	(a)	(a)	185,113	83,821	(a)	(a)			77,794	36,259
Wisconsin			126,675	50,661	678,585	169,166	(a)	(a)			43,424	6,202
Wyoming												
Concealed totals	324,050	255,038	11,509	8,599	423,758	191,206	552,228	174,154	342,681	36,205	32,358	8,724
	1,884,044	1,606,640	3,585,746	2,123,203	22,921,426	6,884,267	969,718	447,513	529,887	181,380	1,560,201	495,724

State.	Paving sand.		Railroad ballast sand.		Other sands.		Gravel.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	(a)	(a)	(a)	(a)	7,294	$2,180	547,656	$116,672	924,701	$242,336
Arizona							(a)	(a)	(a)	(a)
Arkansas			(a)	(a)			831,668	314,003	931,316	352,957
California	173,985	$42,841	45,131	$12,160	59,000	27,571	2,974,090	709,602	3,827,706	977,116
Colorado	(a)	(a)	(a)	(a)			(a)	(a)	(a)	(a)
Connecticut							(a)	(a)	19,350	5,137
Delaware									(a)	(a)
District of Columbia									(a)	(a)
Florida	(a)	(a)	6,470	1,430			16,518	4,495	123,548	34,055
Georgia	(a)	(a)			(a)	(a)	22,848	15,071	572,309	191,447
Hawaii							(a)	(a)	(a)	(a)
Idaho					(a)	(a)	(a)	(a)	(a)	(a)
Illinois	291,436	73,645	(a)	(a)	(a)	(a)	4,424,527	885,548	7,708,012	1,984,569
Indiana	240,053	66,894	1,040,463	76,749	159,950	19,041	2,482,922	591,592	5,998,894	1,235,071
Iowa	293,948	97,008	180,983	25,721	23,967	7,609	1,554,199	313,327	3,002,806	720,795
Kansas	244,103	70,311	(a)	(a)	(a)	(a)	(a)	(a)	1,285,496	378,355
Kentucky	(a)	(a)	(a)	(a)	(a)	(a)	448,897	162,524	944,713	397,764
Louisiana	(a)			(a)	(a)	(a)	(a)	(a)	(a)	(a)
Maine							(a)	(a)	(a)	(a)
Maryland	163,304	71,517			(a)	(a)	854,180	284,410	1,688,427	579,555
Massachusetts	47,239	25,444	(a)	(a)	(a)	(a)	270,906	169,772	747,747	387,371
Michigan	131,466	14,021	(a)	(a)	15,715	2,280	2,457,094	671,970	3,776,726	1,036,739
Minnesota	(a)	(a)	(a)	(a)	(a)	(a)	935,252	175,084	1,508,890	327,975
Mississippi	(a)	(a)	(a)	(a)			991,119	153,627	1,299,813	252,885

a Included in "Concealed totals."

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Sand and gravel produced in the United States in 1915 and 1916—Continued.

1915—Continued

State.	Paving sand.		Railroad ballast sand.		Other sands.		Gravel.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Missouri	(a)	(a)	(a)	(a)	(a)	(a)	1,656,745	$226,716	2,889,211	$675,484
Montana	(a)	(a)			(a)	(a)	7,422	5,500	16,387	13,205
Nebraska	(a)	(a)	71,076	$9,161	(a)	(a)	118,970	27,389	1,075,139	200,920
Nevada							17,491	1,775	17,491	1,775
New Hampshire							583,200	77,760	583,200	77,760
New Jersey	160,256	$53,559			81,095	$22,476	2,112,557	447,388	4,968,104	1,447,557
New Mexico	(a)	(a)					(a)	(a)	(a)	(a)
New York	51,363	21,240					2,828,887	989,801	7,449,807	2,416,522
North Carolina			139,101	40,275			77,241	23,652	424,740	124,697
North Dakota							(a)	(a)	30,240	12,135
Ohio	501,359	194,026	(a)	(a)	94,109	47,617	2,816,132	922,379	6,851,023	2,634,145
Oklahoma			(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Oregon	15,218	14,174	(a)	(a)	283,728	86,612	368,797	118,960	880,633	301,425
Pennsylvania	291,599	106,828	(a)	(a)	86,517	39,470	1,814,902	433,223	6,164,400	2,776,812
Rhode Island					(a)	(a)	(a)	(a)	(a)	(a)
South Carolina			(a)	(a)	(a)	(a)	(a)	(a)	109,011	21,440
South Dakota	(a)	(a)					239,649	36,826	256,270	45,717
Tennessee	13,315	3,552	(a)	(a)			540,653	203,867	1,015,055	376,826
Texas	11,904	2,960	(a)	(a)	(a)	(a)	1,494,421	393,121	1,912,303	533,808
Utah	(a)	(a)	(a)	(a)	(a)	(a)	251,216	29,772	261,611	32,197
Vermont							(a)	(a)	76,590	23,942
Virginia	(a)	(a)	(a)	(a)	(a)	(a)	519,850	126,801	870,219	234,112
Washington	83,827	27,628	(a)	(a)			478,707	129,016	772,629	211,480
West Virginia	69,598	27,230			(a)	(a)	114,273	43,016	723,354	479,685
Wisconsin	206,094	67,340	149,535	9,186	89,410	37,069	1,567,840	349,941	2,862,096	699,915
Wyoming							(a)	(a)	526,837	49,439
Concealed totals	391,150	97,138	1,056,007	175,443	208,465	65,103	1,551,719	443,791	1,496,559	636,492
	3,381,717	1,077,346	2,688,766	350,125	1,109,250	357,028	37,972,548	9,598,391	76,603,308	23,121,617

a Included in "Concealed totals."

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State.	Glass sand.		Molding sand.		Building sand.		Grinding and polishing sand.		Fire or furnace sand.		Engine sand.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama			131,312	$41,470	220,336	$66,989	(a)	(a)			6,199	$1,741
Arizona												
Arkansas			(a)	(a)	78,392	26,371					(a)	(a)
California	(a)	(a)	(a)	(a)	607,641	185,637	(a)	(a)	(a)	(a)	(a)	(a)
Colorado			(a)	(a)	(a)	(a)			(a)	(a)	(a)	(a)
Connecticut			(a)	(a)	58,710	32,564	(a)	(a)				
Delaware			(a)	(a)	(a)	(a)			(a)	(a)		
Florida					71,776	37,777	(a)	(a)				
Georgia	(a)	(a)	3,545	1,756	319,467	77,081	10,091	$3,127			10,889	1,801
Hawaii					(a)	(a)						
Idaho					(a)	(a)						
Illinois	487,432	$318,235	632,529	313,219	2,059,259	597,771	168,088	152,432	(a)	(a)	67,979	12,143
Indiana	(a)	(a)	417,918	173,892	1,226,882	368,699	(a)	(a)			(a)	(a)
Iowa	(a)	(a)	(a)	(a)	1,181,505	388,080	(a)	(a)			19,177	5,296
Kansas					953,306	244,292					(a)	(a)
Kentucky	(a)	(a)	43,160	36,165	414,564	223,642	(a)	(a)	(a)	(a)	9,046	2,243
Louisiana	(a)	(a)			196,107	152,534					(a)	(a)
Maine					(a)	(a)						
Maryland	(a)	(a)	(a)	(a)	825,379	367,130	(a)	(a)			21,553	16,099
Massachusetts	(a)	(a)	26,482	21,812	575,222	248,591	(a)	(a)	(a)	(a)	(a)	(a)
Michigan	(a)	(a)	117,200	81,978	1,234,280	347,499	(a)	(a)	(a)	(a)	(a)	(a)
Minnesota			22,902	15,962	326,693	93,457	(a)	(a)	(a)	(a)	1,921	129
Mississippi			(a)	(a)	43,513	13,649	(a)	(a)			(a)	(a)
Missouri	(a)	(a)	161,788	61,972	766,534	224,863	138,141	66,438	(a)	(a)	35,865	11,836
Montana					(a)	(a)						
Nebraska			(a)	(a)	904,952	174,878					109,108	13,780
Nevada											(a)	(a)
New Hampshire					(a)	(a)						
New Jersey	139,934	115,204	644,611	479,426	1,950,858	417,954	71,708	86,599	62,240	$49,787	68,603	23,318
New Mexico					(a)	(a)					(a)	(a)
New York	(a)	(a)	661,673	570,898	4,331,603	941,884	169,737	46,900	38,144	16,430	66,497	30,144
North Carolina					144,467	30,003	(a)	(a)			(a)	(a)
North Dakota					(a)	(a)					(a)	(a)
Ohio	127,191	129,284	894,802	768,467	3,022,655	1,036,537	61,909	109,092	87,870	100,244	66,228	28,459
Oklahoma	(a)	(a)			222,576	80,287					(a)	(a)
Oregon					161,761	78,610					(a)	(a)
Pennsylvania	534,511	632,702	737,385	590,704	2,706,240	1,223,477	331,160	308,472	152,319	161,404	282,865	194,839
Rhode Island			(a)	(a)								
South Carolina			(a)	(a)	(a)	(a)						

a Included in "Concealed totals."

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Sand and gravel produced in the United States in 1915 and 1916—Continued.

1916—Continued.

State.	Glass sand.		Molding sand.		Building sand.		Grinding and polishing sand.		Fire or furnace sand.		Engine sand.	
	Quantity. (short tons).	Value.	Quantity. (short tons).	Value.	Quantity. (short tons).	Value.	Quantity. (short tons).	Value.	Quantity. (short tons).	Value.	Quantity. (short tons).	Value.
South Dakota					17,553	11,687					(a)	(a)
Tennessee			34,476	15,470	308,545	130,252	(a)	(a)	(a)	(a)	40,428	10,847
Texas	(a)	(a)	(a)	(a)	348,864	$138,952	(a)	(a)	(a)	(a)	13,041	$5,277
Utah					2,865	665					(a)	(a)
Vermont			(a)	(a)	(a)	(a)	(a)	(a)				
Virginia			10,176	$8,609	204,383	51,453	(a)	(a)	(a)	(a)	55,522	8,904
Washington			(a)	(a)	448,943	101,444					(a)	(a)
West Virginia	358,624	$427,339	(a)	(a)	203,744	109,081	37,932	$21,144	(a)	(a)	130,742	60,980
Wisconsin			84,597	56,606	910,453	276,400					42,618	7,520
Wyoming					(a)	(a)					(a)	(a)
Concealed totals	370,625	335,033	36,093	31,433	143,434	69,485	381,588	95,447	86,081	$56,893	334,753	73,158
	2,018,317	1,957,797	4,662,649	3,219,839	27,193,462	8,569,675	1,370,354	889,651	426,654	384,738	1,383,034	508,514

State.	Paving sand.		Filter sand.		Railroad ballast sand and gravel.		Other sands.		Gravel.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	(a)	(a)			259,957	$32,413	(a)	(a)	99,073	$36,264	726,650	$184,216
Arizona					(a)	(a)			(a)	(a)	(a)	(a)
Arkansas	(a)	(a)			(a)	(a)			42,142	22,109	543,902	170,068
California	295,609	$93,112			1,144,352	127,676	15,575	$7,638	2,385,738	594,843	4,480,498	1,036,085
Colorado	(a)	(a)	(a)	(a)	42,027	8,720	(a)	(a)	72,939	37,380	244,208	93,259
Connecticut									(a)	(a)	89,682	53,040
Delaware											9,487	9,721
Florida	(a)	(a)							(a)	(a)	86,452	42,352
Georgia	(a)	(a)	(a)	(a)			(a)	(a)	39,889	20,148	483,615	126,799
Hawaii											(a)	(a)
Idaho	(a)	(a)							(a)	(a)	(a)	(a)
Illinois	90,843	32,803	(a)	(a)	801,192	100,406	665,312	177,152	3,358,153	847,947	8,365,225	2,387,427
Indiana	468,434	142,575			2,555,368	190,829	399,395	101,549	2,753,865	845,197	8,165,989	1,879,078
Iowa	231,300	72,571	31,948	$9,250	924,191	164,800	68,880	23,218	853,277	309,299	3,321,691	980,272

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Kansas	164,995	46,268					(a)	(a)	(a)	(c)	1,164,995	308,630
Kentucky	16,183	9,616			75,665	15,898	(a)	(a)	477,276	171,735	1,053,431	474,216
Louisiana					501,294	54,712	(a)	(a)	842,480	314,088	1,579,701	535,968
Maine					(a)	(a)			(a)	(a)	(a)	(a)
Maryland	(a)	(a)	(a)	(a)			40,394	32,370	864,663	439,955	1,872,159	900,061
Massachusetts	68,694	36,330	(a)	(a)	(a)	(a)	(a)	(a)	329,426	179,066	1,049,577	533,308
Michigan	154,413	38,068	(a)	(a)	392,457	34,289	54,244	11,439	2,226,878	739,311	4,407,475	1,306,256
Minnesota	108,037	33,628	(a)	(a)	(a)	(a)	16,705	3,638	724,240	280,904	1,468,530	491,270
Mississippi	34,532	15,999			781,734	96,631			557,554	190,991	1,435,460	321,509
Missouri	(a)	(a)			937,572	118,856	27,481	5,873	1,364,907	250,728	3,643,205	877,634
Montana							(a)	(a)	290,755	51,398	296,737	55,185
Nebraska	130,402	62,205			(a)	(a)	(a)	(a)	59,829	30,950	1,267,998	289,872
Nevada					(a)	(a)	(a)	(a)			(a)	(a)
New Hampshire					(a)	(a)			(a)	(a)	(a)	(a)
New Jersey	204,104	88,146	26,010	24,755	(b)	(b)	32,617	26,738	c 735,335	c 210,546	3,936,020	1,517,473
New Mexico					(a)	(a)			(a)	(a)	(a)	(a)
New York	83,671	29,282			(a)	(a)	16,512	4,325	2,580,694	980,979	8,098,097	2,644,829
North Carolina	6,850	2,550	(a)	(a)	341,824	75,036	(a)	(a)	(a)	(a)	554,381	150,209
North Dakota									(a)	(a)	(a)	(a)
Ohio	527,383	231,091	(a)	(a)	1,020,823	171,697	79,491	34,469	2,468,722	947,606	8,359,250	3,559,952
Oklahoma	(a)	(a)			(a)	(a)	(a)	(a)	128,290	42,145	574,844	196,206
Oregon	17,735	10,681			182,830	26,791	(a)	(a)	421,060	147,671	904,078	283,493
Pennsylvania	332,368	132,017	(a)	(a)	(a)	(a)	(a)	(a)	2,241,218	734,881	7,442,452	4,023,092
Rhode Island											(a)	(a)
South Carolina	(a)	(a)	(a)	(a)			(a)	(a)	(a)	(a)	54,018	21,211
South Dakota					(a)	(a)			85,207	33,772	1,095,594	133,755
Tennessee	35,076	18,372			(a)	(a)	(a)	(a)	513,687	193,807	1,092,270	414,225
Texas	305,266	101,453			276,362	53,613	25,207	8,862	1,643,209	643,092	2,617,409	957,794
Utah	(a)	(a)			(a)	(a)	(a)	(a)	48,634	9,728	185,569	24,048
Vermont	(a)	(a)			(a)	(a)			(a)	(a)	68,892	34,481
Virginia	5,108	1,665			(a)	(a)	(a)	(a)	293,387	141,803	641,595	226,373
Washington	(a)	(a)							816,811	234,618	1,401,237	387,337
West Virginia	67,867	31,169					(a)	(a)	231,561	108,342	1,054,878	777,952
Wisconsin	152,732	47,887			620,713	91,526	100,958	27,248	1,632,695	337,015	3,544,766	894,202
Wyoming					(a)	(a)	(a)	(a)	707,836	76,657	769,739	86,972
Concealed totals	496,946	153,565	18,095	34,335	2,791,466	415,447	292,136	100,723	586,497	185,882	930,976	221,560
	3,998,548	1,426,053	76,053	68,340	13,649,827	1,779,289	1,834,907	565,242	32,477,927	10,440,857	89,091,732	29,809,995

a Included in "Concealed totals."

b A small output included in "Gravel."

c Includes a small output of "Railroad ballast sand."

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IMPORTS.

Sand valued at $87,144 was imported into the United States in 1916, as compared with imports valued at $96,574 in 1915 and at $139,675 in 1914. This is largely building sand, brought to the United States as ballast or from Canada as a near source of supply, but it includes a small quantity of French molding sand imported for making fine bronze castings, particularly statuary and tablets in relief.

EXPORTS.

The value of exports has not been reported previously, because the Bureau of Foreign and Domestic Commerce included sand and gravel with many other articles under the head "All other articles." In 1916, for the first time, this material was recorded separately, and the table given herewith has been prepared by J. A. Dorsey, of the Survey, from the tables published by the above-mentioned bureau. No information is at hand as to the quantity of sand and gravel represented by these figures nor regarding the character and use of the material. It is surmised that building sand went to Canada from the Great Lakes and Canadian boundary rivers as a convenient source, and it is believed that the sand taken to Panama was a highly refractory silica sand used for steel molding.

Sand and gravel exported from the United States in 1916.

Destination.	Value.	Destination.	Value.
Denmark	$300	Argentina	$600
Spain	420	Brazil	1,029
England	775	China	428
Canada	196,001	Japan	2,554
Panama	8,190	Other countries	12,540
Mexico	7,011		
Newfoundland	1,943		233,310
Cuba	1,519		

GLASS SAND.

GENERAL ASPECTS OF THE INDUSTRY.

The quantity of glass sand produced in the United States passed the 1,000,000-ton mark in 1905; in 1916, for the first time, it exceeded 2,000,000 tons. There has been a tendency in the last few years for the average price per ton to decrease, the lowest price being 85 cents in 1915, but there was a strong recovery in 1916 to 97 cents, as appears from the following table:

Glass sand produced in the United States, 1910–1916.

Year.	Quantity (short tons).	Value.	Average price per ton.
1910	1,461,089	$1,516,711	$1.04
1911	1,538,666	1,543,733	1.01
1912	1,465,386	1,430,471	.97
1913	1,791,800	1,895,991	1.06
1914	1,619,649	1,568,030	.97
1915	1,884,044	1,606,640	.85
1916	2,018,317	1,957,797	.97

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It is believed that the production in 1917 will be considerably greater and that the average price per ton will exceed $1, as an increased output is promised by larger demands and new uses for glass. As a structural material glass has an increasing use—for example, in the larger window area demanded in new office, factory, and school buildings. A new use for glass is in making coffins. A glass coffin molded in one piece, with a hermetically sealed cover, takes the place of a wooden coffin and a steel or slate vault.

GLASS-SAND LOCALITIES.

The resources of the United States in sand suitable for making the more common kinds of glass are very great. Eighteen States produced glass sand in 1916, and it occurs in other States in numerous localities.

Localities where glass sand was reported as produced in 1916.

California: Ione and Lake Majella.
Georgia: Lumber City.
Illinois: Millington, Oregon, and Ottawa.
Indiana: Michigan City.
Iowa: Clayton.
Kentucky: Olive Hill.
Louisiana: Opelousas.
Maryland: Robinson and Hancock.
Massachusetts: Cheshire.
Michigan: Steiner.
Missouri: Crystal City, Klondike, Pacific, and Silica.
New Jersey: Bordentown, Cedarville, Jamesburg, Millville, Penbryn, South Vineland, and Williamstown Junction.
New York: Cleveland.
Ohio: Austintown, Barberton, Howard, Massillon, New Lexington, Silica, and Toboso.
Oklahoma: Hickory, Oklahoma City, and Roff.
Pennsylvania: Daguscahonda, Derry, Dunbar, Falls Creek, Hamilton, Kennerdell, Lewistown, Mapleton, Newton, Parrish, Ridgeway, St. Marys, Torpedo, and Vineyard.
Texas: Santa Anna.
West Virginia: Berkeley Springs, Buckhannon, Independence, Sturgisson, Terra Alta (Holmes Station), and West Berkeley.

REQUIREMENTS OF GLASS SAND.

The factors which determine the value of a deposit for making glass are chemical purity, physical character, quarrying conditions, and location with respect to transportation, cheap fuel, and market.

Glass is a transparent impermeable substance formed by fusing sand, or silica, with fixed alkalies. It is made by melting the ingredients in a pot or tank, mixing the batch thoroughly, and allowing it to cool. It is molded into the desired form while molten. Sand is the principal constituent of all glass, comprising from 52 to 65 per cent of the mass of the original mixture. The qualities of the glass, such as lack of color, brilliance, transparency, and hardness, depend largely, therefore, on the quality of the sand.

For the finest ware only the purest quartz (silica) sand can be employed because slight impurity, especially a small quantity of iron, impairs the brilliance, whiteness, and clearness. Thus, for the manufacture of glass for optical instruments, which is practically colorless, sand, or ground silica, should contain not more than 0.015

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per cent of ferric oxide. Plate and window glass are commonly pale green and absolute purity is not essential in the sand, but more than 0.2 per cent of ferric oxide is undesirable. Green and amber glass for rough structural work, as skylights, sidewalk lights, for bottles, jars, and insulators, are made from sand that has more impurity than is permissible in sand for plate glass and prescription ware.

The suitability of a sand for making glass may be determined roughly by inspecting it for the following properties: The sand should consist almost entirely of quartz, or silica (most glass sands contain from 98 to more than 99 per cent of silica); it should be nearly white or easily washed white; the grains should be uniform in size, either angular or rounded, and preferably should not be larger than 20 mesh nor smaller than 80 mesh. Whiteness is not essential, however, in sand for ordinary window glass and cheap bottles and jars. Sand for window glass that has been dug at a New York locality for many years is pink or dark flesh-colored, and an Indiana sand used for making beer bottles is drab, because of a coating of clay on each of the colorless quartz grains.

Most of the glass sand produced in this country is obtained by crushing soft, crumbly sandstones, but where power is very cheap, it is practicable to produce glass sand by crushing quartzite and vein quartz.

Methods of quarrying and preparing the sand vary somewhat, but in general the quarry face is drilled and shot down with an explosive, and the coarse and fine material is delivered to the mill. If a special quality of sand is desired, selection may be made at the quarry by hand sorting. Large lumps, if very hard, are reduced by a jaw or rotary crusher, but in most places by a less powerful machine, such as a pug mill or muller or a crusher consisting of many heavy hammers revolving rapidly.

Washing the crushed sand is done by two common methods. By one method the sand is carried first upward by a screw conveyor through a long, narrow inclined box against a descending stream of water and then downward in a narrow chute by a second stream of water. This process is repeated three or four times, after which the sand is spilled on a belt conveyor and carried to the draining piles. Another method of washing is by settling tanks. A stream of sand and water is discharged into a tank where the sand settles and impurities are drained off. Sand washed by this method may be left in the last tank to drain, or it may be carried to a draining pile. Sand carried away by the wash water in either process is caught in settling ponds or yards outside the mill and may be used for the various purposes to which a fine-grained silica sand is adapted.

After draining for several hours, or days, the sand is dried, either rapidly in rotary cylindrical driers heated by gases from coke or other smokeless fuel, or slowly by settling through coils of steam pipes, and is then screened and put in stock bins. Glass sand is shipped in bulk in box cars, which are lined with paper to prevent leakage.

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MOLDING SAND.

GENERAL ASPECTS OF THE INDUSTRY.

Under molding sand are included iron, steel, and brass molding sand, core sand, and pig-bed sand.

The effect of the war in Europe on the molding-sand industry in the United States is very apparent. Reports of production made to the United States Geological Survey show an increase of 30 per cent in 1916 over 1915. This great increase was caused by the demand for vast supplies of machinery and munitions for shipment abroad and also for manufacturing and mining machinery for domestic use, all of which required molding sand for casting the metal. The production in 1916 exceeded 4,500,000 tons for the first time and the average price per ton, 69 cents, was the highest yet recorded. The following table shows the fluctuations of the industry since 1910:

Molding sand produced in the United States, 1910–1916.

Year.	Quantity (short tons).	Value.	Average price per ton.
1910	3,636,167	$2,431,254	$0.67
1911	3,376,717	2,132,469	.63
1912	4,485,380	2,718,726	.61
1913	3,563,583	2,230,217	.63
1914	2,751,209	1,756,383	.64
1915	3,585,746	2,121,203	.59
1916	4,662,649	3,219,839	.69

Ohio was the leading State in the production of molding sand; Pennsylvania was second, and New York, New Jersey, and Illinois, in the order named, were the next largest producers. These States are also the largest producers of iron and steel castings, for which the molding sand is used.

SUBSTITUTE FOR FRENCH MOLDING SAND.

Molding sand produced at Fontenay aux Roses, near Paris, France, has been imported for many years for bronze and brass workers. The annual importation is believed to have been about 1,000 casks of 800 pounds weight. The sand is yellow and lumpy and has to be ground and mixed for use. When so prepared it is comparatively even-grained and readily passes a 100-mesh sieve. It is composed almost wholly of quartz, and the grains are mostly subangular, translucent to iron-stained, rarely transparent. This sand has a most durable and tenacious natural bond and is permeable to gases even when packed. It is used for facing molds for fine bronze castings, particularly statuary and tablets in relief.

Many of the bronze molders in this country are Frenchmen, who have a natural preference for the sand with which they learned their trade. The European war has practically stopped the importation of French sand. The United States Geological Survey, in trying to find a

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domestic substitute, has discovered that a sand which promises to be satisfactory occurs at West Albany, N. Y., and at Zanesville, Ohio. Of the West Albany sand, a firm of bronze molders who had been using French sand exclusively wrote: "This sand proved to be just what we wanted." The Zanesville sand is slightly finer grained than the French sand and according to the Bureau of Standards melts at 1,580° C., or 70° lower than the melting point of French sand. After a little experience in their use the molders should be able to get satisfactory results with either of these sands.

BUILDING SAND.

Building sand is used for making plaster, mortar, and concrete. Wall and ceiling plaster, whether made of lime or gypsum, commonly contains a considerable quantity of sand, particularly in the base coat. Mortar used in laying brick, stone, and tile has a body of sand, and sand is a large constituent of much concrete. The reported production of building sand increases annually by reason of larger business and new names added to the list of producers. This sand probably is reported less completely than any other in the foregoing tables because its occurrence is common and widespread, and its use in small amounts by thousands of individuals is not reported to the Survey. The individual use often is only a wagon load or a few tons, but the aggregate of these of which the Survey gets no record must be hundreds of thousands of tons. In many small villages throughout the United States there is no regular dealer in sand and whoever needs a supply gets it from a local deposit. This may be a privately owned sand pit from which the owner may derive a few dollars a year, or it may be the dry bed of a stream from which sand is taken without charge. Obviously the Survey is unable to get a record of this production.

The recorded production in 1916 was 27,193,462 short tons, valued at $8,569,675, an increase of 4,272,036 tons and of $1,685,408 over the production in 1915.

GRINDING AND POLISHING SAND.

Grinding and polishing sands are sharp, tough, hard sands free from clay or foreign material, and sized for use in sawing, cutting, and polishing stone, for grinding and etching glass, and for cleaning metal castings by means of a blast. Blast sand may be either round or angular grains. Pennsylvania is the largest producer and probably the largest user of these sands.

The total production of grinding, polishing, and blast sand in 1916 was 1,370,354 short tons, valued at $889,651. This was an increase of about 40 per cent in quantity and 100 per cent in value over the production of 1915.

FIRE OR FURNACE SAND.

Pennsylvania was the largest producer of fire or furnace sand, which is a highly refractory silica sand used for lining and patching reverberatory and other furnaces, cupolas, and ladles used to contain molten metal. It is also used for making runners for pig-iron casting. Although the quantity produced in 1916 as reported to the Survey

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was less than in 1915, the total value was more than double that of the earlier year. The average price per ton in 1915 was about 34 cents; in 1916 it was 90 cents, and considerable quantities brought well over $1 a ton.

OTHER SANDS.

There seems to have been a slight decrease in the quantity of engine sand used in 1916 but an increase in total value. Paving sand showed a marked increase in both quantity and value. Filter sand, a clean silica sand in sorted sizes used for beds in water-filtration plants and in small mechanical filters, is here reported separately for the first time. The production, as shown in the table on pages 332–333, was largely in Iowa and New Jersey.

In the reports of former years railroad ballast sand has been reported separately and railroad ballast gravel has been lumped with gravel for roofing, concrete, and paving under the one head "Gravel." In tabulating the production of 1916 sand and gravel used for railroad ballast were put together for the reason that much of this ballast is a mixture of sand and gravel and not distinctly one or the other. The change results in much larger figures for railroad ballast and decreases the reported production of gravel by several million tons.

The grand total of sand and gravel produced in the United States in 1916 shows an increase of more than 12,000,000 short tons and in value of more than $6,600,000.

CHATS AND VOLCANIC ASH.

The tables of production given above do not include a considerable quantity of chats or tailings from the Missouri zinc mines. This waste product, which is used on roads, has a nominal value of 15 cents a ton, or the cost of loading. The shipment of chats in Missouri in 1916, as reported by the Missouri Bureau of Geology and Mines, was 2,890,970 tons, compared with 2,309,191 tons in 1915.

Neither do the tables include a considerable quantity of volcanic ash mined and used in California for railroad ballast. This material weighs 2,400 pounds per cubic yard, was valued at $967, and is not included in the tables of other chapters of Mineral Resources for 1916.

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CEMENT.[1]

By Ernest F. Burchard.

INTRODUCTION.

The year 1916 proved a busy period for the cement industry in most parts of the United States. Labor troubles caused the temporary suspension of operations at a few Portland cement plants in the Mississippi Valley, but no plants were embarrassed by lack of business. In 1914 and 1915 there was a decrease in the production of cement, consumers having exercised strict economy in its use, but the year 1916 showed a reaction, it having opened with a demand unprecedented for a midwinter season. Prices of Portland cement, which averaged only 86 cents a barrel for the entire year 1915, began to rise toward the end of that year and continued to do so until well toward the close of 1916, so that the average price per barrel in bulk at the mills for the year was $1.103, an increase of 24.3 cents, or 28.3 per cent. The increased prices, of course, did not mean an equivalent net increase in returns to the manufacturers, because the cost of fuel, explosives, machinery parts, bags, labor, and in fact the costs of all the items that enter into the manufactured product rose considerably during the year. The comparatively high prices did not, however, check the demand for cement. Many manufacturers sold all they could produce and others drew heavily on stocks. The net decrease in stocks for the country at large was more than 3,000,000 barrels, or 27.1 per cent, as compared with the quantity on hand at the close of 1915. Every commercial district but one showed a decrease in stocks on hand.

Another significant feature of the Portland cement industry was the completion of six new manufacturing plants in 1916. The location of these plants (noted on page 358) was influenced as largely by commercial considerations as by proximity of raw materials. So few cement plants have been built in the last five years that the addition of so much capacity in 1916 is of interest.

The United States Geological Survey is issuing in 1917 a bulletin entitled "Our mineral supplies," which deals mainly with the relation of these supplies to war demands. The chapter on Portland cement, issued in separate form as Bulletin 666–S, in July, 1917, contains data that otherwise would probably have appeared here. The topics discussed in that chapter comprise raw materials, distribution

[1] The statistics in this chapter were prepared by Mrs. H. L. Bennit, of the United States Geological Survey, with the exception of those showing imports and exports, which were compiled by J. A. Dorsey.

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of mills, military importance of Portland cement, independence of the cement industry, conditions in the industry during war years, consumption of cement, and needs of the industry which might be fulfilled by governmental agencies.

One suggestion with regard to the usefulness of concrete that was not mentioned in Bulletin 666–S is that because under war conditions structural steel is expensive, difficult to obtain, and greatly needed in construction of ships and for many military purposes, every effort should be made to substitute reinforced concrete for structural steel where possible. That this is possible has already been pointed out by prominent architects, and the Portland Cement Association contends that many buildings could as well be erected with far less steel by the use of reinforced concrete. Inasmuch as the supply of raw material for the production of concrete is practically unlimited and is still relatively cheap, it would seem that an increased use of concrete for this purpose would not only release a large quantity of structural steel and in that way prove a war measure, but would also prove economical to the building industry.

The production of potash as a by-product of the manufacture of hydraulic cement, which was noted in the chapter on cement in 1915, has been discussed in greater detail elsewhere,[1] and will therefore not be taken up here. The chapter on potash discusses first, the general features of the problem, the source, the quantity of potash contained in the raw materials, and the principles involved in its recovery. Then follows a description of the methods of collecting and treating the potash-bearing dust at the plants of the Riverside Portland Cement Co., Riverside, Cal.; the Security Cement & Lime Co., Hagerstown, Md.; the Buffalo Potash & Cement Corporation, Buffalo, N. Y.; the Alpha Portland Cement Co., Alsen, N. Y.; and the Southwestern Portland Cement Co., Victorville, Cal.

The map showing the distribution of cement plants in the United States which has appeared from time to time in Mineral Resources has been revised and is issued again in the present chapter. A bibliography of Federal and State Survey publications on cement and concrete is also given herewith.

MARKETED PRODUCTION OF PRINCIPAL HYDRAULIC CEMENTS.

The total quantity of Portland, natural, and puzzolan cements marketed or shipped from the mills in the United States in 1916 was 95,394,433 barrels, valued at $104,689,090, as compared with 87,685,222 barrels, valued at $75,155,102, in 1915. This represents an increase in quantity of 7,709,211 barrels, or 8.8 per cent, and an increase in value of $29,533,988, or 39.3 per cent. It should be noted here that a table in which the statistics of these three kinds of cement are combined to form a total in barrels is necessarily slightly inconsistent, for the weights per barrel of the various kinds of cement are different. A barrel of Portland cement is supposed to weigh 376 pounds net, but the weights of barrels of cement of the other

[1] Gale, H. S., Potash in 1916: U. S. Geol. Survey Mineral Resources, 1916, pt. 2, pp. 73–171, 1917.

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two classes are not uniform. Natural cement is sold in barrels containing 240 to 285 pounds and generally supposed to contain 265 pounds; puzzolan cement has been supposed to weigh 330 pounds to the barrel, but barrels of it weighing from 240 to 380 pounds have been reported, the weight depending on the specific gravity of the cement, its fineness, and the number of sacks constituting a barrel. It would insure uniformity if all cements could be sold by the hundredweight.

The distribution of the total marketed production of the three main classes of cement for 1914–1916 is shown in the following table:

Principal hydraulic cements shipped from factories in the United States in 1914, 1915, and 1916.

Class.	1914		1915		1916	
	Quantity (barrels).	Value.	Quantity (barrels).	Value.	Quantity (barrels).	Value.
Portland	86,437,956	$80,118,475	86,891,681	$74,756,674	94,552,206	$104,258,216
Natural	751,285	351,370	750,803	358,627	842,127	430,874
Puzzolan	68,311	63,358	42,678	39,801		
	87,257,552	80,533,203	87,685,222	75,155,102	95,394,433	104,689,090

The historical table that follows gives the production and value of natural, Portland, and puzzolan cements so far as recorded by the Survey. The curves in figure 9 show graphically some of these data from 1880 to 1916. The figures represent actual production of Portland cement for all years and of natural and puzzolan cements until 1911, inclusive, after which the figures for these cements represent marketed production or shipments. In 1916 there was but one manufacturer of puzzolan cement; hence the shipments of puzzolan are included with those of natural cement. No figures for production or stocks are collected for natural and puzzolan cements because production and shipments are generally nearly the same and stocks are relatively small.

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Principal hydraulic cements produced in the United States, 1818–1916.

Year.	Natural cement.		Portland cement.		Puzzolan cement.		Total.	
	Quantity (barrels).	Value.	Quantity (barrels).	Value.	Quantity (barrels).	Value.	Quantity (barrels).	Value.
1818–1829	300,000	$246,000					300,000	$246,000
1830–1839	1,000,000	850,000					1,000,000	850,000
1840–1849	4,250,000	3,612,500					4,250,000	3,612,500
1850–1859	11,000,000	9,350,000					11,000,000	9,350,000
1860–1869	16,420,000	13,957,000					16,420,000	13,957,000
1870–1879	22,000,000	18,700,000	82,000	$246,000			22,082,000	18,946,000
1880	2,030,943	1,726,707	42,000	126,000			2,072,943	1,852,707
1881	2,440,000	2,379,000	60,000	150,000			2,500,000	2,529,000
1882	3,165,000	3,481,500	85,000	191,250			3,250,000	3,672,750
1883	4,100,000	4,100,000	90,000	193,500			4,190,000	4,293,500
1884	3,900,000	3,510,000	100,000	210,000			4,000,000	3,720,000
1885	4,000,000	3,200,000	150,000	292,500			4,150,000	3,492,500
1886	4,350,000	3,697,500	150,000	292,500			4,500,000	3,990,000
1887	6,692,744	5,186,877	250,000	487,500			6,942,744	5,674,377
1888	6,253,295	4,533,639	250,000	487,500			6,503,295	5,021,139
1889	6,531,876	4,702,951	300,000	500,000			6,831,876	5,202,951
1890	7,441,116	3,822,501	335,500	704,050			7,776,616	4,526,551
1891[a]	7,767,979	3,671,147	454,813	967,679			8,222,792	4,638,826
1892	8,211,181	3,991,455	547,440	1,152,600			8,758,621	5,144,055
1893	7,411,815	3,251,757	590,652	1,158,138			8,002,467	4,409,895
1894	7,563,488	3,635,731	798,757	1,383,473			8,362,245	5,019,204
1895	7,741,077	3,895,424	990,324	1,586,830			8,731,401	5,482,254
1896	7,970,450	4,049,202	1,543,023	2,424,011	12,265	$12,250	9,525,738	6,485,463
1897	8,311,688	3,862,392	2,677,775	4,315,891	48,329	48,500	11,037,792	8,226,783
1898	8,418,924	3,888,728	3,692,284	5,970,778	233,000	198,050	12,344,208	10,057,551
1899	9,868,179	4,814,771	5,652,266	8,074,371	335,000	268,000	15,855,445	13,157,142
1900	8,383,519	3,728,848	8,482,020	9,280,525	365,611	274,208	17,231,150	13,283,581
1901	7,084,823	3,056,278	12,711,225	12,532,360	272,689	198,151	20,068,737	15,786,789
1902	8,044,305	4,076,630	17,230,644	20,864,078	478,555	425,672	25,753,504	25,366,380
1903	7,030,271	3,675,520	22,342,973	27,713,319	525,896	542,502	29,899,140	31,931,341
1904	4,866,331	2,450,150	26,505,881	23,355,119	803,045	226,651	31,675,257	26,031,920
1905	4,473,049	2,413,052	35,246,812	33,245,867	382,447	272,614	40,102,308	35,931,533
1906	4,055,797	2,423,170	46,463,424	52,466,186	481,224	412,921	51,000,445	55,302,277
1907	2,887,700	1,467,302	48,785,390	53,992,551	557,252	443,998	52,230,342	55,903,851
1908	1,686,862	834,509	51,072,612	43,547,679	151,451	95,468	52,910,925	44,477,656
1909	1,537,638	652,756	64,991,431	52,858,354	160,646	99,453	66,689,715	53,610,563
1910	1,139,239	483,006	76,549,951	68,205,800	95,951	63,296	77,785,141	68,752,092
1911	926,091	378,533	78,528,637	66,248,817	93,230	77,786	79,547,958	66,705,136
1912	821,231	367,222	82,438,096	67,016,928	91,864	77,363	83,351,191	67,461,513
1913	744,658	345,889	92,097,131	92,557,617	107,313	97,663	92,949,102	93,001,169

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1914	751,285	351,370	88,230,170	81,789,368	68,811	63,358	89,049,766	82,204,096
1915	750,863	358,627	85,914,907	73,886,820	42,678	39,801	86,708,448	74,285,248
1916	[b] 842,137	[b] 430,874	91,521,198	100,947,881	(c)	(c)	92,363,335	101,378,755
	235,165,554	149,610,518	947,954,336	911,423,835	4,806,757	3,937,695	1,187,926,647	1,064,972,048

[a] The figures for 1890 and previous years are estimates made at the close of each year and are believed to be substantially correct. For years since 1890 the official figures are based on practically complete returns from all producers.

[b] Includes puzzolan cement.

[c] Included with natural cement.

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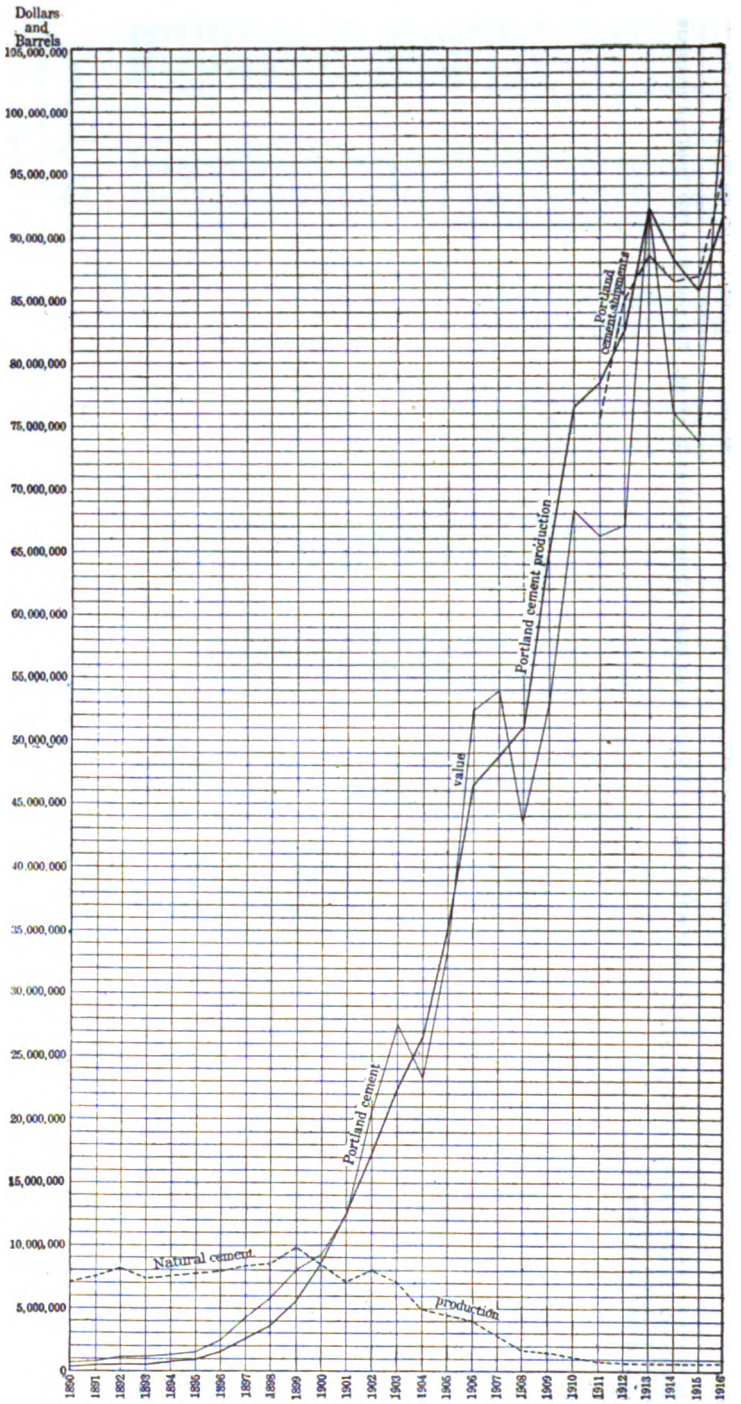

FIGURE 9.—Production of Portland and natural cements, 1890–1916, and shipments of Portland cement, 1911–1916. Natural cement includes puzzolan cement in 1916.

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PORTLAND CEMENT.

PRODUCTION AND SHIPMENTS.

The total production of Portland cement in the United States in 1916, as reported to the United States Geological Survey, was 91,521,198 barrels, valued at $100,947,881. This represents an increase in quantity of 6.5 per cent and in value of 36.6 per cent. The value assigned is computed at a price of $1.103 a barrel, the average price of the Portland cement shipped in 1916.

The shipments of Portland cement from the mills in the United States in 1916 were, according to reports received by the Survey, 94,552,296 barrels, valued at $104,258,216, an increase in quantity of 7,660,615 barrels, or 8.8 per cent, and in value of $29,501,542, or 39.5 per cent. The average price per barrel for the whole country in 1916, according to these figures, was $1.103, compared with $0.86 in 1915, an increase of 24.3 cents a barrel, or 28.3 per cent. This represents the selling price of cement in bulk at the mills, including cost of labor and packing, but not the value of the sacks or barrels. The average price per barrel for the country is 15.9 cents higher than the average price received for Portland cement in the Lehigh district and is near the average price received in Indiana, Kansas, Missouri, the Ohio-western Pennsylvania district, and the southern Indiana-Kentucky district, but falls 54.1 cents below the average received in Utah, where Portland cement brought the highest price ($1.644) of the year.

The quantity of Portland cement made in 1916 (91,521,198 barrels of 376 pounds) was approximately equivalent to 15,362,487 gross tons, and the price per ton was about $6.57. The quantity of Portland cement made in 1916 was equivalent to 39 per cent of the quantity of pig iron produced in that year (39,434,797 gross tons), but the total value of the cement was 15 per cent of the value of the pig iron. The average price of the cement per ton was 39 per cent of that of pig iron.

The average price of Portland cement in the United States has been increased slightly over the average for ordinary gray cement by the inclusion in the total shipments of a small quantity of white Portland cement. This white cement was produced in the Lehigh district, so that the value for that district has been increased in greater proportion than that of the other districts. Two mills, both in Pennsylvania, reported the production of white Portland cement in 1916.

PRODUCTION AND SHIPMENT, BY STATES.

In the following table the production and shipments and the corresponding values of Portland cement for 1915 and 1916, by States, are arranged in alphabetical order, provided there are three or more producers or shippers in a single State, or permission is given to publish figures where there are less than three. By the term "producer" is meant a Portland-cement manufacturing company, whether the company operates one or more plants. In the table the term "producing plant" is applied to a mill or group of mills located at one

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73°
69°
65°
45°
41°
37°
33°
29°
25°
81°
77°
Key West
BAHAMA ISLANDS
Charleston
Jacksonville
Tallahassee
Montgomery
Atlanta
Birmingham
Chattanooga
Knoxville
Nashville
Louisville
Cincinnati
Columbus
Pittsburgh
Harrisburg
Philadelphia
Baltimore
Washington
Richmond
Norfolk
Lynchburg
Roanoke
Raleigh
Wilmington
Charlotte
Greensboro
Greenville
Spartanburg
Asheville
Augusta
Macon
Columbia
Savannah
Portland
Augusta
Bangor
Concord
Portsmouth
Boston
Albany
Syracuse
Rochester
Buffalo
Scranton
Binghamton
Trenton
Newark
New York
Providence
Hartford
Springfield
Worcester
Lowell
Lawrence
Manchester
Nashua
Keene
Burlington
Rutland
Montpelier
Barre
Brattleboro
Bennington
Pittsfield
Northampton
Fitchburg
Gardner
Leominster
Haverhill
Newburyport
Salem
Lynn
Cambridge
Somerville
Medford
Malden
Everett
Chelsea
Revere
Quincy
Brockton
Taunton
New Bedford
Fall River
Pawtucket
Woonsocket
Newport
Middletown
Norwalk
Stamford
Bridgeport
New Haven
Waterbury
New Britain
Meriden
Hartford
Willimantic
Norwich
New London
Groton
Danbury
Torrington
Winsted
Litchfield
Derby
Ansonia
Shelton
Milford
Stratford
Fairfield
Westport
Norwalk
Greenwich
Stamford
Rye
Mount Vernon
New Rochelle
Yonkers
White Plains
Peekskill
Poughkeepsie
Kingston
Hudson
Albany
Troy
Schenectady
Amsterdam
Gloversville
Johnstown
Utica
Rome
Oneida
Syracuse
Auburn
Seneca Falls
Geneva
Canandaigua
Rochester
Batavia
Lockport
Niagara Falls
Buffalo
Tonawanda
North Tonawanda
Olean
Salamanca
Jamestown
Dunkirk
Fredonia
Westfield
Ripley
Erie
Meadville
Titusville
Oil City
Franklin
Warren
Corry
Union City
Girard
Conneaut
Ashtabula
Painesville
Mentor
Willoughby
Euclid
Cleveland
Lakewood
Rocky River
Lorain
Elyria
Sandusky
Fremont
Toledo
Bowling Green
Findlay
Tiffin
Fostoria
Bucyrus
Marion
Galion
Mansfield
Ashland
Wooster
Orrville
Akron
Barberton
Cuyahoga Falls
Kent
Ravenna
Warren
Youngstown
Niles
Sharon
New Castle
Beaver Falls
Rochester
Aliquippa
Ambridge
Sewickley
Coraopolis
McKees Rocks
Bellevue
Avalon
Sharpsburg
Etna
Aspinwall
Verona
Oakmont
Tarentum
Brackenridge
Natrona
Freeport
Kittanning
Ford City
Parker
Butler
Zelienople
Evans City
Mars
Sewickley
Ambridge
Aliquippa
Beaver Falls
New Castle
Ellwood City
Grove City
Mercer
Sharon
Farrell
Wheatland
Sharpsville
Greenville
Hermitage
Sharon
Mercer
Grove City
Slippery Rock

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relations of the Portland cement plants to their trade territory. These relations are, of course, governed largely by transportation facilities and rates, and in forming the districts it has been found advisable to divide Pennsylvania, Indiana, and Texas in order to group the plants commercially. Possibly other divisions may be made in future reports. (See Pl. II.)

According to this table there was in 1916, compared with 1915, an increase in shipments in every district except Illinois-northwestern Indiana, and an increase in production in all except Lehigh and Maryland-Virginia-West Virginia districts. The decrease, however, was very small. The largest percentage of increase in both shipments and production was in the Rocky Mountain district, respectively, 28.1 per cent and 25.3 per cent; Iowa-Minnesota-Missouri, southern Indiana-Kentucky, Nebraska-Kansas-Oklahoma-central Texas, and the Pacific coast districts also showed noteworthy increase.

The net change for the whole country was an increase in shipments of 7,660,615 barrels, or 8.8 per cent, and an increase in production of 5,606,291 barrels, or 6.5 per cent. In 1916 shipments exceeded production by 3,031,098 barrels.

Portland cement shipped and produced in 1915 and 1916, by districts.

[Figures opposite S relate to shipments; those opposite P to production.]

Commercial district.		Active plants.		Shipments and production (barrels).			Average factory price per barrel.		
		1915	1916	1915	1916	Percentage of change, 1916.	1915	1916	Percentage of change, 1916.
Lehigh district (eastern Pennsylvania and western New Jersey).	S	20	20	24,598,950	25,360,287	+ 3.1	$0.699	$0.944	+35.1
	P	19	20	24,876,442	24,105,381	− 3.1	.....	.....	.....
New York	S	8	9	5,275,101	5,603,477	+ 6.2	.766	1.027	+34.1
	P	7	9	5,043,889	5,643,677	+11.9	.....	.....	.....
Ohio and western Pennsylvania.	S	8	8	7,528,383	8,123,492	+ 7.9	.855	1.113	+30.2
	P	8	8	7,300,498	7,936,731	+ 8.7	.....	.....	.....
Michigan and northeastern Indiana.	S	13	13	5,480,428	5,747,113	+ 4.9	.944	1.168	+23.7
	P	13	13	5,485,951	5,521,876	+ .7	.....	.....	.....
Southern Indiana and Kentucky.	S	3	3	2,762,941	3,266,215	+18.2	.703	1.106	+57.3
	P	3	3	2,828,561	3,238,942	+14.5	.....	.....	.....
Illinois and northwestern Indiana.	S	6	5	10,879,655	10,637,659	− 2.2	.907	1.056	+16.4
	P	5	5	10,242,869	10,360,563	+ 1.1	.....	.....	.....
Maryland, Virginia, and West Virginia.	S	4	4	3,166,721	3,315,323	+ 4.7	.816	1.009	+23.7
	P	4	4	3,193,805	3,189,585	− .1	.....	.....	.....
Tennessee, Alabama, and Georgia.	S	5	5	3,099,770	3,541,572	+14.3	.756	.980	+29.6
	P	5	5	3,010,037	3,502,259	+16.4	.....	.....	.....
Iowa, Minnesota,[a] and Missouri.	S	8	9	9,218,820	11,178,790	+21.3	.882	1.187	+34.6
	P	8	9	9,186,401	10,592,234	+15.3	.....	.....	.....
Nebraska[b], Kansas, Oklahoma, and central Texas.	S	15	15	6,517,258	7,735,418	+18.7	.872	1.168	+33.9
	P	15	15	6,274,863	7,502,111	+19.6	.....	.....	.....
Rocky Mountain States (Colorado, Utah, Montana, and western Texas).	S	7	7	2,453,095	3,141,855	+28.1	1.289	1.527	+18.5
	P	7	7	2,472,069	3,097,385	+25.3	.....	.....	.....
Pacific Coast States (California, Oregon,[a] and Washington).	S	12	15	5,910,559	6,901,095	+16.8	1.375	1.458	+ 6.0
	P	12	15	5,999,522	6,830,454	+13.8	.....	.....	.....
Total	S	109	113	86,891,681	94,552,296	+ 8.8	.860	1.103	+28.3
	P	106	113	85,914,907	91,521,198	+ 6.5	.....	.....	.....

[a] No output, 1915. [b] No output, 1916.

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The United States Geological Survey has collected the statistics of shipments of Portland cement during the last six years, and these data are summarized as follows:

Portland cement shipped from mills in the United States, 1911–1916.

Year.	Quantity (barrels).	Value.
1911	75,547,829	$63,762,368
1912	85,012,556	69,109,800
1913	88,689,377	89,106,975
1914	86,437,956	80,118,475
1915	86,891,681	74,756,674
1916	94,552,296	104,258,216

LEHIGH DISTRICT.

The production of Portland cement in the Lehigh district, in eastern Pennsylvania and western New Jersey, in 1916 was 24,105,381 barrels, a decrease of 771,061 barrels, or 3.1 per cent, compared with 1915. The shipments from mills in this district in 1916 amounted to 25,360,287 barrels, an increase of 761,337 barrels, or 3.1 per cent, over 1915. The total value of the Portland cement shipped from this district in 1916 was reported as $23,929,361, at an average price of 94.4 cents a barrel in bulk at the mills, as compared with $17,204,920, or 69.9 cents a barrel, in 1915. The production of white Portland cement from two plants in this district is included in the figures for 1916. As the average price reported for the white cement was considerably higher than that reported for ordinary gray cement, the average price for the district is slightly higher than if it represented gray Portland cement alone.

Twenty plants produced and shipped Portland cement from the Lehigh district in 1916, as compared with 19 producers and 20 shippers in 1915.

The Lehigh district has, except in six years, shown a steady increase in production of Portland cement from 1890 to the present time. The years in which slight decreases were recorded are 1893, 1908, 1911, 1912, 1914, and 1916. The first two decreases were coincident with years of general business depression, but the decrease in 1911 and 1912 may perhaps be attributed in large part to overproduction in 1910 and to the building of many mills in other parts of the United States, which have restricted the trade territory of the Lehigh district. The reason for the moderate decline in 1916 is not so clear, as the most of the new plants are in localities remote from the Lehigh district; but the entrance of a new plant into the Hudson River region in New York may have affected the result. The shipments, however, as noted above, showed an increase. The percentage which the Lehigh output bears to the total output for the United States has decreased each year since 1899, except in 1907 and 1915.

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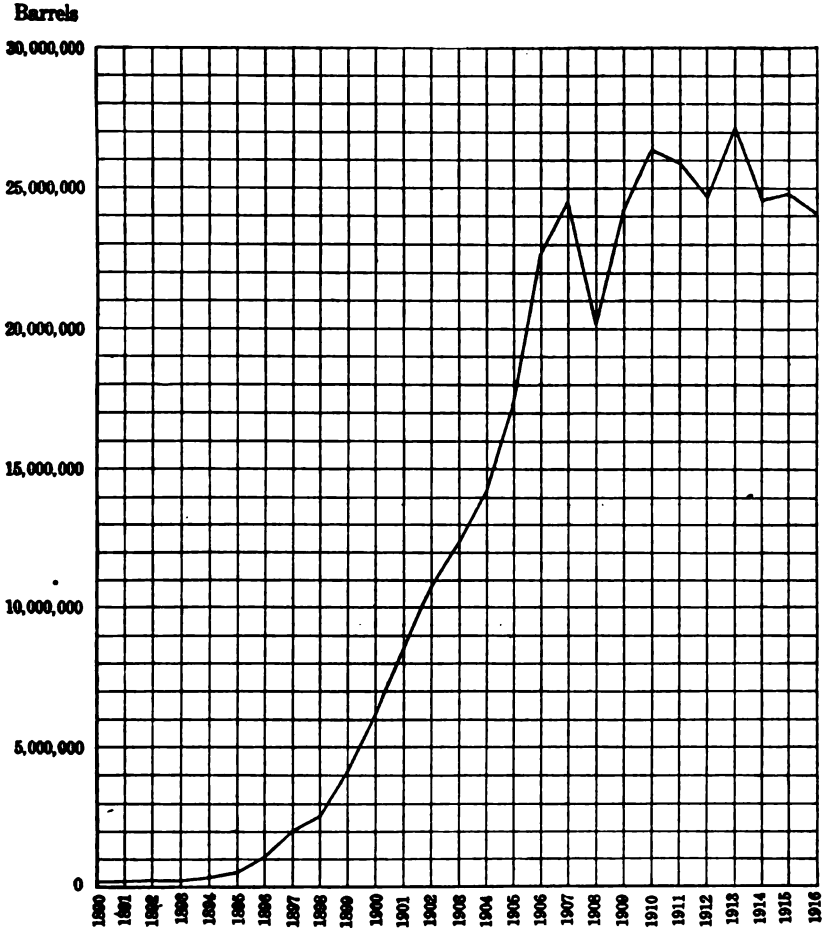

FIGURE 10.—Production of Portland cement in the Lehigh district, 1890–1916.

Portland cement produced in the Lehigh district and in the United States, 1890–1916.

Year.	Lehigh district (barrels).	United States (barrels).	Percentage made in Lehigh district.	Year.	Lehigh district (barrels).	United States (barrels).	Percentage made in Lehigh district.
1890	201,000	335,500	60.0	1904	14,211,039	26,505,881	53.7
1891	248,500	454,813	54.7	1905	17,368,087	35,246,312	49.3
1892	280,840	547,440	51.3	1906	22,784,613	46,463,424	49.0
1893	265,317	590,552	44.9	1907	21,417,086	48,785,390	50.0
1894	485,329	798,757	60.8	1908	20,200,387	51,072,612	39.6
1895	634,776	990,324	64.0	1909	24,246,706	64,991,431	37.3
1896	1,048,154	1,543,023	68.1	1910	26,315,359	76,549,951	34.4
1897	2,002,059	2,677,775	74.8	1911	25,972,108	78,528,037	33.1
1898	2,674,304	3,692,284	72.4	1912	24,762,083	82,438,096	30.0
1899	4,110,132	5,652,266	72.7	1913	27,139,601	92,097,131	29.5
1900	6,153,029	8,482,020	72.6	1914	24,614,933	88,230,170	27.9
1901	8,595,340	12,711,225	67.7	1915	24,876,442	85,914,907	29.0
1902	10,829,922	17,230,644	62.8	1916	24,105,381	91,521,198	26.3
1903	12,324,922	22,342,973	55.2				

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STOCKS AT MILLS.

The stock of Portland cement on hand at the various factories at the end of 1916, according to reports, amounted to 8,360,478 barrels, compared with 11,462,523 barrels on hand at the close of 1915, a decrease in stock of 3,102,045 barrels, or 27.1 per cent, during 1916. The stocks at many factories in 1915 were revised by the producers, at the request of the Survey, and the stock reported for 1916 checks with the revised total for 1915 within 0.85 per cent of the stock calculated by balancing the shipments for 1916 against the production of 1916, plus the stock at the close of 1915, and it is believed that this agreement is as close as it can be made, for the volume of stocks can not be measured with great accuracy.

State and district stocks at the close of 1915 and 1916 and the United States totals at the close of each of the last six years are given in the next three tables.

Portland cement in stock Dec. 31, 1915, and Dec. 31, 1916, by States.

State.	Quantity (barrels).		Percentage of change in 1916.
	1915 (revised).	1916	
California	476,060	521,970	+ 9.6
Illinois	453,474	526,341	+16.1
Indiana	1,494,490	1,195,891	−20.0
Iowa	578,587	428,011	−26.0
Kansas	316,368	212,810	−32.7
Michigan	569,919	336,477	−41.0
Missouri	861,717	307,538	−64.3
New Jersey	164,341	183,812	+11.8
New York	729,436	787,532	+ 8.0
Ohio	205,063	181,481	−11.5
Pennsylvania	3,794,644	2,366,062	−37.6
Texas	260,671	146,746	−43.7
Utah	87,370	88,105	+ .8
Washington	490,534	272,913	−43.2
Other States[a]	989,849	804,769	−18.7
	11,462,523	8,360,478	−27.1

[a] Includes Alabama, Colorado, Georgia, Kentucky, Maryland, Montana, Oklahoma, Tennessee, Virginia, and West Virginia in 1915, with Minnesota and Oregon additional in 1916.

Portland cement in stock Dec. 31, 1915, and Dec. 31, 1916, by districts.

State.	Quantity (barrels).		Percentage of change in 1916.
	1915 (revised).	1916	
Lehigh district (New Jersey and eastern Pennsylvania)	3,400,936	2,156,825	−36.6
New York	729,436	787,532	+ 8.0
Ohio and western Pennsylvania	763,112	574,550	−24.7
Michigan and northeastern Indiana	677,608	451,724	−33.3
Kentucky and southern Indiana	501,432	477,232	− 4.8
Illinois and northwestern Indiana	1,479,474	1,193,341	−19.3
Maryland, Virginia, and West Virginia	359,913	235,511	−34.6
Tennessee, Alabama, and Georgia	279,445	237,395	−15.0
Iowa, Minnesota,[a] and Missouri	1,440,304	852,549	−40.8
Kansas, Nebraska,[b] Oklahoma, and central Texas	632,245	380,695	−39.8
Rocky Mountain States (Colorado, Utah, Montana, and western Texas)	242,024	198,984	−17.8
Pacific coast States (California, Oregon,[a] and Washington)	956,594	814,140	−14.9
	11,462,523	8,360,478	−27.1

[a] No stock, 1915. [b] No stock, 1916.

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Portland cement in stock in the United States at the end of the years 1911 to 1916.

	Barrels.		Barrels.
1911	10,385,789	1914	12,773,463
1912	7,811,329	1915	11,462,523
1913	11,220,328	1916	8,360,478

PORTLAND CEMENT CONSUMED PER CAPITA.

In the chapter on the cement industry in Mineral Resources for 1914 a table was presented for the first time to show the consumption of Portland cement in the States and the dependencies of the United States. The consumption by States is not absolute, as it is represented only by the records of shipments by manufacturers into the several States. Of course, the shipments of cement into a State do not equal the consumption in that State during the same period, but if taken for a long period they should afford a very fair index to that consumption. The consumption in the outlying possessions of the United States is represented simply by the official statistics of exports to those countries from the United States. The simplest available common index appears to be the estimated consumption per capita in barrels, which has been obtained by comparing the shipments into States and possessions with the population for the States and possessions in 1915 and 1916 as estimated by the Bureau of the Census.

In the per capita consumption tables formerly presented for 1914 and 1915 the Philippine Islands were included, but in preparing the tables for 1916 it has been thought best to omit the data concerning these islands because the exports from the United States are so small and the population of the islands so large that the per capita consumption figured on this basis is negligible, and also if the population is carried in the total it lowers materially the average for the United States, which, therefore, has been revised slightly for 1915. The table of exports to other countries shows the shipments of cement from the United States to the Philippines, but there are no data available as to the imports of cement to the islands from foreign countries, which, of course, should figure in their per capita consumption.

The discrepancy between the official figures of the Bureau of Foreign and Domestic Commerce for exports of cement, given on page 366, and the exports reported by manufacturers, as given in the next table, is due to the following facts: Cement shipped from mills destined for foreign countries is reported by the shipper as exported. He does not know whether or not it leaves the country during that calendar year, but the Bureau of Foreign and Domestic Commerce bases its export figures on the cement that actually leaves the country, according to its records. The exports given by that bureau include all natural or puzzolan cement which may have been exported, whereas the table of per capita consumption given below relates only to Portland cement. Another source of apparent disagreement is the fact that the lump figure for unspecified exports reported by manufacturers does not include the exports to Alaska, Hawaii, and Porto Rico, statistics for which are given separately in the same table.

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The per capita consumption shown by the table necessarily falls short of the total apparent consumption by the quantity of the imports. These, however, are small—only 42,218 barrels in 1915 and 1,836 barrels in 1916; but there are no data to show just which States consumed the imported cement.

The highest per capita consumption in 1916 was that of Iowa (1.77). Michigan (1.58) and California (1.51) followed. In 1915 Iowa led with a per capita consumption of 1.54, and California and Minnesota stood second and third, their per capita consumption being, respectively, 1.46 and 1.40. In 1916 the per capita consumption was more than 1 barrel in 17 States; 14 States exceeded this quantity in 1915. In 1916 eight of these divisions were west of Mississippi River and five of them were west of the Rocky Mountains, but in 1915 only four of the larger cement-consuming States were in the area west of Mississippi River. This change is consistent with the increase in production and shipments in the Great Plains, Rocky Mountain, and Pacific Coast States in 1916, indicated in foregoing tables. Comparison of the figures by States for the last two years brings out some wide variations and abrupt changes in the estimated consumption per capita. All of the 52 divisions apparently showed change; 36 showed increases and 16 showed decreases. All the decreases except two were in Eastern and Southern States. Especially noteworthy increases in 1916 occurred in Indiana and Michigan, each 27 per cent; in North Carolina, 24 per cent; and in Arizona, Idaho, Utah, and Wyoming, which showed 51, 42, 25, and 29 per cent, respectively. The general average per capita consumption for all the United States and dependencies was 0.77 barrel in 1914, 0.83 barrel in 1915, and 0.89 barrel in 1916. When the changes in per capita consumption by States are examined it may be inferred that large decreases or increases have been due mostly to changes in demand for cement for public works.

The estimate of per capita consumption follows:

Estimated per capita consumption of Portland cement in the United States and outlying possessions in 1915 and 1916.

State.	1915			1916		
	Population (estimated).	Consumption (shipments to States).	Estimated consumption per capita.	Population (estimated).	Consumption (shipments to States).	Estimated consumption per capita.
		Barrels.	*Barrels.*		*Barrels.*	*Barrels.*
Alabama	2,301,277	384,568	0.17	2,332,608	474,797	0.20
Alaska	64,757	34,347	.53	64,834	36,739	.57
Arizona	247,299	220,220	.89	255,544	359,001	1.40
Arkansas	1,713,102	276,756	.16	1,739,723	297,215	.17
California	2,848,275	4,004,672	1.46	2,938,654	4,434,425	1.51
Colorado	935,799	540,962	.58	962,060	659,554	.69
Connecticut	1,223,583	1,642,516	1.34	1,244,479	1,618,711	1.30
Delaware	211,598	171,981	.81	213,380	182,499	.86
District of Columbia	358,679	441,417	1.23	363,980	434,841	1.19
Florida	870,802	483,039	.55	893,493	474,478	.53
Georgia	2,816,289	617,124	.22	2,856,065	804,882	.28
Hawaii	211,902	169,732	.80	215,741	205,681	.95
Idaho	411,996	242,872	.59	428,586	434,529	1.01
Illinois	6,069,519	6,732,906	1.11	6,152,257	7,749,121	1.26
Indiana	2,798,142	2,950,657	1.06	2,816,817	3,749,207	1.33

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Estimated per capita consumption of Portland cement in the United States and outlying possessions in 1915 and 1916—Continued.

State.	1915			1916		
	Population (estimated).	Consumption (shipments to States).	Estimated consumption per capita.	Population (estimated).	Consumption (shipments to States).	Estimated consumption per capita.
		Barrels.	*Barrels.*		*Barrels.*	*Barrels.*
Iowa	2,358,066	3,633,369	1.54	2,220,321	3,930,325	1.77
Kansas	1,807,221	1,762,393	.98	1,829,545	2,049,797	1.12
Kentucky	2,365,185	827,909	.35	2,379,639	879,203	.37
Louisiana	1,801,306	776,177	.43	1,829,130	617,375	.34
Maine	767,638	437,935	.57	772,489	395,684	.51
Maryland	1,351,941	1,367,732	1.01	1,362,807	1,250,389	.92
Massachusetts	3,662,339	2,911,949	.80	3,719,156	2,922,834	.79
Michigan	3,015,442	3,950,532	1.31	3,054,854	4,820,946	1.58
Minnesota	2,246,761	3,143,999	1.40	2,279,603	3,338,560	1.46
Mississippi	1,926,778	194,319	.11	1,951,674	247,559	.13
Missouri	3,391,789	2,892,781	.85	3,410,692	2,801,674	.82
Montana	446,054	575,076	1.29	459,494	662,150	1.44
Nebraska	1,258,624	1,250,010	.99	1,271,375	1,471,443	1.16
Nevada	102,730	42,523	.41	106,734	52,433	.49
New Hampshire	440,584	342,031	.78	442,506	245,933	.56
New Jersey	2,881,840	3,498,663	1.22	2,948,017	3,424,009	1.16
New Mexico	396,917	252,278	.64	410,283	189,834	.46
New York	10,086,568	10,372,387	1.02	10,273,375	10,081,041	.98
North Carolina	2,371,095	570,472	.24	2,402,738	1,146,329	.48
North Dakota	713,083	246,793	.35	739,201	415,125	.56
Ohio	5,088,627	7,074,563	1.39	5,150,356	7,646,792	1.48
Oklahoma	2,114,307	671,714	.32	2,202,081	1,090,643	.50
Oregon	809,490	536,060	.66	835,741	522,764	.63
Pennsylvania	8,383,992	7,320,813	.87	8,522,017	7,554,715	.89
Porto Rico	1,200,286	228,473	.19	1,216,083	257,019	.21
Rhode Island	602,765	378,027	.63	614,315	368,686	.60
South Carolina	1,607,745	272,115	.17	1,625,475	463,347	.29
South Dakota	680,046	430,229	.63	698,509	581,492	.83
Tennessee	2,271,379	736,397	.32	2,288,004	949,502	.41
Texas	4,343,710	1,741,228	.40	4,429,566	2,193,460	.50
Utah	424,300	421,184	.99	434,083	539,721	1.24
Vermont	362,452	209,173	.58	363,699	202,065	.56
Virginia	2,171,014	1,178,465	.54	2,192,019	1,103,787	.50
Washington	1,471,043	1,034,201	.70	1,534,221	1,298,559	.85
West Virginia	1,359,474	1,067,967	.79	1,386,038	994,047	.72
Wisconsin	2,473,533	3,164,581	1.28	2,500,350	3,290,721	1.32
Wyoming	174,148	115,169	.66	179,559	170,677	.95
Unspecified		120,067			92,922	
	102,013,291	84,663,518	.83	103,513,970	92,179,242	.89
Exports reported by manufacturers, but not included above		2,228,163			2,373,054	
Total shipped from cement plants		86,891,681			94,552,296	

TOTAL QUANTITY CONSUMED.

An estimate of the total consumption of Portland cement in the United States may be made by adding the imports to the shipments and subtracting the exports from the sum. Of course, a variable but considerable stock of cement is at all times in transit, in warehouses at distributing points, and awaiting use on the ground at large jobs, so that the estimate thus made is, at best, approximate. Still another uncertain element in this estimate is the fact that as imports and exports are classed as hydraulic cement the records do not discriminate between Portland and other cements. Portland cement, however, constitutes by far the greater part of the exports, and, as the tables show, the imports are small. The apparent domestic consump-

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tion in 1916 amounted to 91,990,156 barrels, and in 1915 it was about 84,368,868 barrels, an increase of 7,621,288 barrels, or about 9 per cent, as compared with a decrease of 0.06 per cent in 1915.

The following table gives the figures necessary for estimates of consumption so far as available, as prior to 1911 no records are at hand for stocks:

Apparent domestic consumption of Portland cement, 1911–1916, in barrels.

Year.	Shipments.	Imports.	Exports.	Apparent consumption.
1911	75,547,829	164,670	3,135,409	72,577,090
1912	85,012,556	68,503	4,215,532	80,865,527
1913	88,689,377	85,470	2,964,358	85,810,489
1914	86,437,956	120,906	2,140,197	84,418,665
1915	86,891,681	42,218	2,565,031	84,368,868
1916	94,552,206	1,836	2,563,976	91,990,156

PRICES.

Average prices of Portland cement per barrel in bulk at the factories are shown in the tables of shipments by States and districts during 1915 and 1916. According to these figures, the price in 1916 ranged between 94.4 cents in the Lehigh district and $1.644 in Utah, as compared with 69.9 cents in the Lehigh district and $1.399 in California, respectively, in 1915. The average price for the whole country was $1.103 in 1916, as compared with 86 cents in 1915, an increase of 24.3 cents per barrel, or 28.3 per cent. Inspection of the State table shows that in every State and district there were increases in average price. The States whose increases were above the average increase for the whole country were Indiana, Iowa, Kansas, New Jersey, New York, Pennsylvania, and Utah, and the districts that showed more than the average increase in price were Lehigh, Ohio-western Pennsylvania, southern Indiana-Kentucky, Tennessee-Alabama-Georgia, Iowa-Minnesota-Missouri, and Great Plains States.

Figure 11 illustrates graphically the rapid early decline and the recent fluctuations in the general average prices of Portland cement, and the accompanying table summarizes the same data.

Average factory price per barrel in bulk of Portland cement, 1870–1916.

1870–1880	$3.00	1895	$1.60	1907	$1.11
1881	2.50	1896	1.57	1908	.85
1882	2.01	1897	1.61	1909	.813
1883	2.15	1898	1.62	1910	.891
1884	2.10	1899	1.43	1911	.844
1885–1888	1.95	1900	1.09	1912	.813
1889	1.67	1901	.99	1913	1.005
1890	2.09	1902	1.21	1914	.927
1891	2.13	1903	1.24	1915	.860
1892	2.11	1904	.88	1916	1.103
1893	1.91	1905	.94		
1894	1.73	1906	1.13		

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MANUFACTURING CONDITIONS.

Portland cement was manufactured at 113 plants in 1916, compared with 106 plants in 1915. Six new plants reported production in

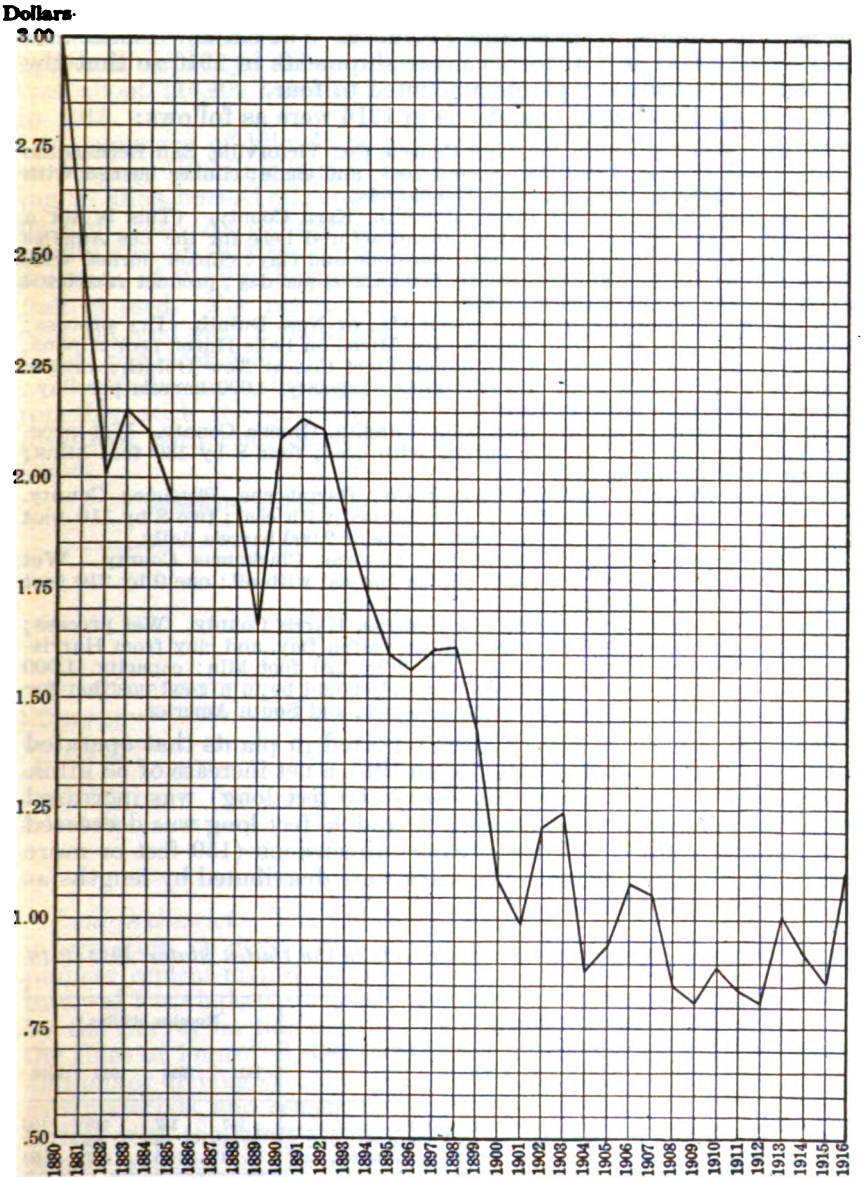

FIGURE 11.—Range in average factory price per barrel of Portland cement, 1880–1916.

1916, one each in California, Minnesota, New York, Oklahoma, Oregon, and Texas, and in addition one plant in California, idle for some years, reported production. Two plants suspended produc-

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tion—one each in Kansas and Nebraska, and one plant each in New Jersey and New York, idle in 1915, resumed operations in 1916—a net gain of seven producing plants.

Shipments were reported from 113 plants in 1916, compared with 109 plants in 1915, three plants having suspended shipments in 1916—one each in Illinois, Kansas, and Nebraska. The six new plants and the revived plant in California made shipments in 1916 so that the net increase in shipping plants amounted to four.

The plants that began operations in 1916 were as follows:

California.—Southwestern Portland Cement Co., Victorville, San Bernardino County. Wet process; limestone, cement rock, and shale; clinker burned with oil; one 9 by 200 foot kiln; capacity, 850 barrels.

Los Angeles County cement plant, Monolith, Kern County. (This is not a newly built plant, cement having been manufactured here for the Los Angeles aqueduct in 1910–1912.) Dry process; limestone and clay; clinker burned with oil; four 10 by 110 foot kilns; capacity, 800 barrels per day; product restricted to public works in Los Angeles County.

Minnesota.—Universal Portland Cement Co., at New Duluth. Dry process; limestone brought by boat from Rogers City, Mich., on Lake Huron near Alpena, and slag from blast furnaces of Minnesota Steel Co., at New Duluth; clinker burned with coal; four 10 by 150 foot kilns; capacity, 4,000 barrels per day; Cottrell dust precipitating system.

New York.—Acme Cement Corporation, Catskill, Greene County. Wet process; limestone and clay; clinker burned with coal; four 8 by 160 foot kilns; capacity, 2,500 barrels daily.

Oklahoma.—Choctaw Portland Cement Co., Hartshorne, Pittsburg County. Dry process; limestone and shale; clinker burned with coal; two 8 by 110 foot kilns and one 8 by 125 foot kilns; capacity, about 2,000 barrels daily.

Oregon.—Oregon Portland Cement Co., Oswego, Clackamas County. Wet process; limestone and cement rock; clinker burned with oil; one 9 by 210 foot kiln; capacity, 1,100 barrels daily.

Texas.—Texas Portland Cement Co., Houston, Harris County. Wet process; uses oyster shells dredged from a reef in Galveston Bay, and clay from Harrisburg, Tex.; clinker burned with oil; one 9 by 220 foot kiln; capacity, 1,000 barrels daily. This plant is on tidewater and should be in a good position for export trade with West Indies, Central America, and South America.

The total number of rotary kilns reported in plants that operated in 1916 was 807, compared with 754 in 1915, a net increase of 53 kilns. The number of active small kilns (40 to 60 feet long) was increased by 29; the number of kilns between 60 and 90 feet long was decreased by 5; and 22 additional kilns of large dimensions (150 feet or more long) were reported in use. The kilns were distributed by lengths as shown in the table below:

Lengths of rotary cement kilns in active plants in the United States, 1913–1916.

Length (feet).	Number of kilns.				Length (feet).	Number of kilns.			
	1913	1914	1915	1916		1913	1914	1915	1916
40 to 60	157	170	99	128	125	157	157	148	150
60 to 90	145	133	124	119	125 to 140	63	63	63	62
100	93	94	86	81	150 or more	38	46	47	69
110	117	76	88	89					
120	103	100	99	109		873	839	754	807

The apparent total annual kiln capacity in 1916 of all the plants, either active or only temporarily closed, according to the producers' reports, due allowance being made for the customary loss of time

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from breakdowns and from necessary shutdowns for repairs, was about 134,000,000 barrels of Portland cement, compared with about 129,800,000 barrels in 1915, estimated on the same basis. According to these figures the total production for 1916 (91,521,198 barrels) was 68.3 per cent of the cement-producing capacity of the country, whereas the production in 1915 represented 66.2 per cent of the apparent capacity. The apparent average output per kiln in 1916 was about 113,400 barrels, as compared with about 113,900 barrels in 1915.

A summary of kiln fuels reported in 1916 shows that 87 plants, employing 643 kilns, burned powdered coal; that 17 plants, employing 96 kilns, burned oil; and that 2 plants, employing 10 kilns, burned natural gas. As compared with 1915 there was an increase of 3 plants and of 46 kilns burning coal; an increase of 2 plants, but a decrease of 9 kilns burning oil. At certain plants more than one fuel is used. For instance, 2 plants report coal and oil; 1 plant, coal, oil, and gas; 1 plant, coal and gas; 2 plants, oil and gas; and 1 plant, producer gas.

The following table summarizes these data for 1915 and 1916, together with the quantities and percentages of Portland cement produced with coal, oil, and gas, and with two or more of these fuels:

Summary of Portland cement kiln fuels in 1915 and 1916.

Fuel.	1915.				1916.			
	Number of plants.	Number of kilns.	Barrels of cement.	Percentage of total.	Number of plants.	Number of kilns.	Barrels of cement.	Percentage of total.
Coal	84	597	70,440,529	82.0	87	643	74,844,603	81.8
Coal and oil	1	24	5,124,074	6.0	2	32	4,948,917	5.4
Coal, oil, and gas	1	5	729,797	.8	1	5	914,531	1.0
Coal and gas	1	7	830,988	1.0	1	7	697,410	.8
Oil	15	105	7,581,467	8.8	17	96	8,041,026	8.8
Oil and gas	1	5	469,762	.5	2	13	957,797	1.0
Producer gas	1	1	72,777	.1	1	1	76,951	.1
Natural gas	2	10	665,513	.8	2	10	1,039,963	1.1
	106	754	85,914,907	100.0	113	807	91,521,198	100.0

Lehigh district.—The following notes, derived from local sources of information, on developments during the last five or six years in the pioneer cement-manufacturing district, are of interest, as a longer interval has elapsed since comprehensive information was published by the Survey on this locality. The developments are chiefly along the lines of improved quarry methods, installation of electric power and motor driving systems, and of finer grinding machinery for coal, raw materials, and cement clinker. Finer grinding of the clinker is in line with the latest standard specifications and tests for Portland cement adopted by the American Society for Testing Materials, to become effective January 1, 1917, which are noted more fully on pages 363 and 365.

The plant of the Edison Portland Cement Co., New Village, N. J., started operations early in 1917 after having been shut down for over a year. During this period the system of grinding the raw

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materials and cement clinker was changed. These materials were formerly crushed in large Edison crushing rolls and the product of the rolls was passed through large separating chambers, where the fine material was separated from the coarse. The air-separating system has been abandoned and the product, after passing through the rolls, is now delivered to large tube mills.

The plant of the Vulcanite Portland Cement Co., Vulcanite, N. J., has had considerable remodeling during the last few years. New crushing equipment has been installed, consisting of a 60-inch by 42-inch Fairmount crushing roll in the cement rock quarries, and the method of handling the cars from the quarry to the crusher has been changed. The quarry arrangement now is reported to be one of the best in this district. In the coal grinding and raw grinding departments all tube mills have been removed and 42-inch Fuller mills have been installed. In the kiln department some of the small kilns, which were only 60 feet long, have been replaced with kilns 8 feet 6 inches in diameter and 125 feet long.

The two plants of the Alpha Portland Cement Co., located at Alpha, N. J., known as Plants No. 1 and No. 2, have not been in operation for a considerable period.

At the two plants, No. 3 and No. 4, of the Alpha Portland Cement Co., Martins Creek, Pa., there has been considerable quarry and plant development. The quarries which were formerly known as No. 3 and No. 4 have now been joined into one large quarry, and large gyratory crushers have been placed in the floor of the quarry convenient to each plant. Air drills have been superseded by deep well drills permitting blasting rock from the entire face of the quarry at one time. Heretofore the quarry was worked in 16-foot benches. Steam shovels are now extensively used and large railroad cars have replaced most of the horses and carts formerly used for transporting the rock from the quarry to the crusher. The horse and cart system is still used in remote portions of the quarry for trimming purposes. In the coal-grinding departments Fuller mills have replaced the tube mills formerly in operation. In the raw-grinding department of plant No. 3 the tube mills have been replaced by Fuller mills.

During the last few years the plant of the Nazareth Cement Co., Nazareth, Pa., has been entirely remodeled. All the short kilns have been replaced by kilns 120 feet long. The tube mills in the coal-grinding department have been replaced with Fuller mills. All the machinery in the plant is now driven by means of individual motors, and the power is purchased from the Lehigh Coal & Navigation Co. Heretofore the company generated its own power, and all the different departments were line-shaft driven by one large engine, all the separate units being driven off the main line-shaft with rope drives. The quarry arrangement has been altered and a large gyratory crusher has been installed. A new stock house and packing house have also been constructed. In the floor of the stock house are tunnels through which the cement may be drawn out and delivered to the packing house.

The Pennsylvania Cement Co., Bath, Pa., has replaced all its small kilns with large kilns 9 feet in diameter and 125 feet in length. The tube mills have been replaced in the coal-grinding department by Fuller mills. All departments of the plant are now electrically

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driven, the power being purchased from the Eastern Power Co. This plant formerly generated its own power and its various departments were line-shaft driven. After all changes have been made each unit will be driven by its own motor.

At the Bath Portland Cement Co., Bath, Pa., considerable development work in both the quarry and the plant has been done recently. Deep-well drills are now in use, and the rock blasted down from the quarry is loaded on cars by means of steam shovels. The horse-and-cart system has been entirely eliminated. This plant generates its own power. Originally the plant was a line-shaft driven plant, but the drives are gradually being changed so that each unit will be driven by means of motors. All the Griffin mills in the coal-grinding and raw-grinding departments have been replaced with Fuller mills. A large clinker storage has been built. This storage is provided with a large overhead crane traveling on the retaining walls of the storage system. This crane is provided with a grab bucket which not only takes the hot clinker from the kilns and distributes it to the storage but also harvests the seasoned clinker and delivers it to the conveyor serving the clinker-grinding department.

Considerable plant development has been done of late by the Phoenix Portland Cement Co., Nazareth, Pa. The short kilns have been replaced by 100-foot kilns. Emerick mills and air separators have replaced tube mills for raw grinding. The plant was originally line-shaft driven, but is gradually being changed over to an electrically driven system, some of the power being purchased from the Eastern Power Co.

In connection with the installation of the large kilns at the plant of the Dexter Portland Cement Co., Nazareth, Pa., driers for the raw materials have been recently installed. These driers are connected to the kilns, so that the waste gases from the kilns can be utilized to dry the raw material.

The Hercules Cement Corporation, Stockertown, Pa., has taken over the plant of the Atlantic Cement Co. Construction on this plant was started about 12 years ago, but the plant was never operated by the former company. At the present time (July, 1917) two kilns are reported operating.

The plant of the Northampton Portland Cement Co., Stockertown, Pa., has been taken over by the Atlantic Potash Co. The kilns formerly used for burning cement will be used for treating feldspar or greensand by heat in an endeavor to manufacture potash for agricultural purposes.

The property of the Lily White Portland Cement Co., Nazareth, Pa., has been taken over by the Industrial Limestone Co., and there is now in operation a lime plant consisting of five vertical kilns. In addition to burning lime agricultural limestone is also prepared, the material being ground in 42-inch Fuller mills.

Considerable quarry and plant development has been done at the plant of the Lawrence Portland Cement Co., Siegfried, Pa. The limestone quarry at North Catasauqua has been abandoned and the old quarry of the former Bonneville Cement Co. at Siegfried is now operated. This quarry is approximately 300 feet deep and a plane has been installed so that the rock can be hauled up from the pit to a Fairmount crusher placed in a tower at the head of the plane.

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This plant was formerly line-shaft driven, but power is now purchased from the Lehigh Coal & Navigation Co. and all units are driven by means of individual motors. The small kilns have been replaced with longer kilns.

Plants No. 2 and No. 4 of the Atlas Portland Cement Co., Northampton, Pa., have been in steady operation. Plant No. 3, at Northampton, and the Valley mill, or plant No. 1, at Coplay, have been out of service for about 10 years. At plant No. 4 two kilns have been installed for manufacturing white cement. Preliminary tests on 12-foot diameter kilns were made at plant No. 3 and a large kiln 10 feet in diameter by 175 feet long was installed at plant No. 4. A 42-inch Fuller mill was recently installed in the coal-grinding department at plant No. 2 to replace Huntington mills, and some tube mills for grinding raw materials have been added.

The Whitehall Cement Manufacturing Co., at Cementon, Pa., has made considerable quarry development and plant improvement recently. The entire plant is electrified and the power is generated in the company's power house. All the short kilns have been replaced by kilns 120 feet long. Some large tube mills have been installed for grinding raw materials and clinker. A new coal milling plant is now being constructed, and this plant will be fitted up with four 42-inch Fuller mills, replacing Griffin mills and tube mills. An additional kiln is now being installed.

The Coplay Cement Manufacturing Co., Coplay, Pa., has completely remodeled its two plants known as mill B and mill C. The tube mills and Griffin mills formerly operated in the coal-grinding and raw-grinding departments of mill B have been replaced with Fuller mills. The ball mills and tube mills formerly operated in the coal-grinding and raw-grinding departments at mill C have also been replaced with Fuller mills. In addition, Fuller mills have been installed in the clinker-grinding departments of both mill B and mill C. Both plants were formerly line-shaft driven plants. All the different units are driven by means of individual motors, the power being purchased from the Lehigh Coal & Navigation Co. At present mill B is being operated as a magnesite calcining plant, for preparation of refractory materials. All the short kilns of mill B have been replaced with kilns 125 feet long. At mill C some of the short 60-foot kilns are still in service, but there have been added kilns 125 feet long, some 7 feet in diameter and others 9 feet in diameter. It is planned to install the Cottrell dust-collecting system in connection with the kilns at both mills B and C and waste-heat boilers in connection with kilns at both plants.

The Giant Portland Cement Co., Egypt, Pa., has taken over the properties of the American Cement Co. and is now operating two plants, known as the Central mill and the Reliance mill.

The Lehigh Portland Cement Co. is reported to have done some remodeling at its plants at West Coplay and Omrod, but no details are available concerning the changes that have been made, further than that some Griffin mills have been replaced by larger Griffin mills.

The plant of the Allentown Portland Cement Co., Evansville, Pa., was put into operation in 1910. All the departments are electrically driven, each unit being driven by means of an individual motor. The coal grinding, raw grinding, and clinker grinding are done by Fuller mills.

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STANDARD SPECIFICATIONS.

The most recent standard specifications and tests for Portland cement are those adopted by the United States Government and by the American Society for Testing Materials and published recently by the Bureau of Standards.[1] They became effective January 1, 1917, and are the result of several years' work of a special committee representing the United States Government, the American Society of Civil Engineers, and the American Society for Testing Materials. The specification is as follows:

UNITED STATES GOVERNMENT SPECIFICATION FOR PORTLAND CEMENT.

DEFINITION.

1. Portland cement is the product obtained by finely pulverizing clinker produced by calcining to incipient fusion an intimate and properly proportioned mixture of argillaceous and calcareous materials, with no additions subsequent to calcination excepting water and calcined gypsum.

CHEMICAL PROPERTIES.

Chemical limits.—2. The following limits shall not be exceeded:

	Per cent.
Loss on ignition	4.00
Insoluble residue	.85
Sulphuric anhydride (SO_3)	2.00
Magnesia (MgO)	5.00

PHYSICAL PROPERTIES.

Specific gravity.—3. The specific gravity of cement shall be not less than 3.10 (3.07 for white Portland cement). Should the test of cement as received fall below this requirement a second test may be made upon an ignited sample. The specific-gravity test will not be made unless specifically ordered.

Fineness.—4. The residue on a standard No. 200 sieve shall not exceed 22 per cent by weight.[2]

Soundness.—5. A pat of neat cement shall remain firm and hard and show no signs of distortion, cracking, checking, or disintegration in the steam test for soundness.

Time of setting.—6. The cement shall not develop initial set in less than 45 minutes when the Vicat needle is used or 60 minutes when the Gillmore needle is used. Final set shall be attained within 10 hours.

Tensile strength.—7. The average tensile strength in pounds per square inch of not less than three standard mortar briquets (see sec. 51) composed of one part cement and three parts standard sand, by weight, shall be equal to or higher than the following:

Age at test.	Storage of briquets.	Tensile strength, pounds per square inch.
7 days	1 day in moist air, 6 days in water	200
28 days	1 day in moist air, 27 days in water	300

8. The average tensile strength of standard mortar at 28 days shall be higher than the strength at 7 days.

[1] United States Government specification for Portland cement: U. S. Dept. Commerce Bur. Standards Circular 33, 3d ed., 43 pp., Jan. 18, 1917.

[2] The United States Government specification requires that on and after July 1, 1918, the residue on the standard No. 200 sieve shall not exceed 20 per cent by weight.

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PACKAGES, MARKING, AND STORAGE.

Packages and marking.—9. The cement shall be delivered in suitable bags or barrels with the brand and name of the manufacturer plainly marked thereon, unless shipped in bulk. A bag shall contain 94 pounds net. A barrel shall contain 376 pounds net.

Storage.—10. The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment and in a suitable weather-tight building which will protect the cement from dampness.

INSPECTION.

11. Every facility shall be provided the purchaser for careful sampling and inspection at either the mill or at the site of the work, as may be specified by the purchaser. At least 10 days from the time of sampling shall be allowed for the completion of the 7-day test, and at least 31 days shall be allowed for the completion of the 28-day test. The cement shall be tested in accordance with the methods hereinafter prescribed. The 28-day test shall be waived only when specifically so ordered.

REJECTION.

12. The cement may be rejected if it fails to meet any of the requirements of these specifications.

13. Cement shall not be rejected on account of failure to meet the fineness requirement if upon retest after drying at 100° C. for one hour it meets this requirement.

14. Cement failing to meet the test for soundness in steam may be accepted if it passes a retest using a new sample at any time within 28 days thereafter.

15. Packages varying more than 5 per cent from the specified weight may be rejected; and if the average weight of packages in any shipment, as shown by weighing 50 packages taken at random, is less than that specified, the entire shipment may be rejected.

After these articles of specification the subject of tests is taken up in detail in the Bureau of Standards circular, which prescribes the methods by which samples shall be taken and the various determinations made and gives the percentage of permissible variation in results. The types of apparatus for making certain of the tests and analyses are illustrated by diagrams. Then follows an explanation of changes made in revising the original United States Government specification for Portland cement, which gives the old version and the new version and discusses the changes made and the reasons therefor.

Some of the more important changes made in the specification are as follows:

The maximum limit for sulphuric anhydride (SO_3) has been increased from 1.75 per cent to 2 per cent; the magnesia (MgO) limitation was raised from 4 per cent to 5 per cent; the requirement for fineness was changed by eliminating the requirement on the No. 100 sieve, by requiring a residue of not more than 22 per cent by weight in place of 25 per cent on the No. 200 sieve, and by permitting only 20 per cent on and after July 1, 1918; the requirement for soundness was changed by omitting the test on neat cement pats exposed to air and water for 28 days and by retaining only the test of a neat cement pat exposed in an atmosphere of steam for five hours; in the tests for tensile strength the neat cement tests were eliminated and the requirement at 28 days for mortar (1 part cement to 3 parts standard Ottawa sand) strength was increased from 275 pounds to 300 pounds.

The maximum limit for magnesia has been set at 5 per cent, as it has been established that this quantity is not injurious, and it is high enough to permit the use of larger quantities of raw material available in most parts of the country and may thereby reduce the cost of manufacture in some places.

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On the subject of fineness it is pointed out in the Bureau of Standards circular that only the extremely fine powder of cement called flour possesses appreciable cementing qualities, the coarser particles adding little or nothing to the cementing value. Sieves are not made fine enough to determine the flour in a cement, nor is there any other generally applied means of accurately and practically measuring the flour. Some cements grind more easily than others and thus, although a larger percentage of one cement may pass the 200-mesh sieve than of another, the former may have a smaller percentage of actual flour because of the difference in the hardness and the character of the clinker and the methods of grinding. The cementing value of different cements can not be compared directly by their apparent fineness through a 200-mesh sieve; but as to cement from the same mill, made by the same grinding machinery and from similar clinker, it is probable that the greater the percentage which passes the 200-mesh sieve the greater the percentage of flour in that particular cement. Data at present available indicate that all Portland cements have greater cementing value as the fineness is increased; for instance, the results of a comprehensive series of tests in a number of laboratories with several brands of cement showed an average increase of 2 per cent in compressive strength at the age of one month for each increase of 1 per cent in fineness between the limits considered, which varied from 77 to 83 per cent. Tests have indicated that the majority of cement mills are now meeting the requirement of 22 per cent residue, and that a number are meeting the requirement of 20 per cent. It is the opinion of the departmental committee that fine grinding is a step in the right direction.

FOREIGN TRADE IN CEMENT.

EXPORTS.

In 1916 the total quantity of hydraulic cement exported to foreign countries, including the Philippines and the Panama Canal Zone, was 2,563,976 barrels, most of it Portland cement, valued at $3,828,231 at the United States ports of shipment, or an average of approximately $1.49 a barrel, as compared with 2,565,031 barrels, valued at $3,361,451, or about $1.31 a barrel, in 1915. The quantity exported in 1916 was not quite 2.8 per cent of the total production of hydraulic cements, as compared with about 3 per cent exported in 1915. The decrease in quantity in 1916 amounted to 0.04 per cent.

The exports have never been great, the largest quantity, that in 1912, having been only 4,215,532 barrels. The exports for 1915, however, showed an increase of nearly 20 per cent over those of 1914, and, as this increase was due largely to greater exports to South America and the West Indies, it appears that the cement trade had begun to expand in the direction of the greatest promise, but the sudden check in the total exports in 1916 indicates a shortage of ships and possibly limited markets. An examination of the table shows that there were relatively large increases in exports to Bolivia, Colombia, Cuba, Dutch Guiana, Dutch West Indies, Ecuador, French West Indies, Haiti, Salvador, and Trinidad, but those to Argentina, Brazil, Honduras, Mexico, Panama, and Uruguay decreased notably. Exports to Canada and England decreased, whereas those to Newfoundland showed a large percentage of increase.

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The following table affords a comparison of the details of exports by countries for the last two years:

Hydraulic cement exported from the United States in 1915 and 1916.[a]

Destination.	1915		1916	
	Quantity (barrels).	Value.	Quantity (barrels).	Value.
Argentina	118,454	$153,025	37,690	$56,720
Australia	645	1,983	455	878
Azores and Madeira Islands	25	32		
Bermuda	2,037	3,758	6,642	9,972
Bolivia	1,918	2,651	109,986	142,215
Brazil	430,938	520,366	184,053	263,298
British East Africa			60	90
British Guiana	18,058	23,386	18,175	29,147
British Honduras	2,732	4,269	1,055	1,804
British India	191	557	487	606
British Oceania	35	63	438	1,013
British South Africa	1,440	1,867	825	1,619
British West Africa	166	219	12,658	18,304
British West Indies:				
Barbados	4,140	5,417	2,154	3,215
Jamaica	38,941	52,213	42,861	65,093
Trinidad and Tobago Islands	30,205	39,499	41,932	60,468
Other British West Indies	8,601	11,691	12,921	19,866
Canada	28,764	46,879	20,001	31,337
Canary Islands	1,092	2,054		
Chile	66,848	89,743	65,248	98,080
China			253	592
Colombia	45,669	59,457	74,354	107,953
Costa Rica	17,974	25,714	16,225	29,126
Cuba	579,738	788,047	802,682	1,206,174
Danish West Indies (Virgin Islands)	1,201	1,781	1,420	3,068
Dominican Republic	57,285	75,743	63,036	96,733
Dutch East Indies	2,527	4,009	5,295	12,208
Dutch Guiana	3,791	5,169	8,181	12,747
Dutch West Indies	8,621	12,797	16,256	28,794
Ecuador	28,801	39,127	36,338	57,087
England	18,167	25,586	1,955	4,174
Egypt			3	5
France	90	113		
French Guiana	680	908	1,350	2,053
French Oceania	100	198	539	1,068
French West Indies	7,005	10,377	12,208	19,398
German Oceania			280	622
Guatemala	15,014	19,937	18,196	30,323
Haiti	19,866	27,163	44,898	67,068
Honduras	21,894	39,993	9,736	16,588
Hongkong	1	3	40	100
Italy	1,000	1,244	4	7
Japan	21	59	20	60
Japanese China	438	895		
Liberia	438	649		
Mexico	112,533	191,633	92,925	179,950
Miquelon, Langley, etc			100	211
Netherlands	12	32	5	7
Newfoundland	13,438	15,434	25,571	35,354
New Zealand	337	423	62	83
Nicaragua	7,555	12,958	9,154	17,738
Norway			275	394
Panama	686,024	823,363	609,278	842,847
Peru	88,170	116,023	84,615	132,085
Philippine Islands	65	151	130	232
Portugal	10	14	2,000	3,200
Portuguese Africa	501	727	1,358	2,462
Russia in Asia			30	60
Salvador	21,262	36,067	27,322	53,023
Scotland	5	8		
Spain	92	124	20	37
Straits Settlements			2	3
Turkey in Asia	453	1,394		
Uruguay	13,115	17,161	1,985	3,072
Venezuela	34,906	47,298	38,234	57,770
Total	2,565,031	3,361,451	2,563,976	3,828,231

[a] Statistics compiled from records of Bureau of Foreign and Domestic Commerce, Department of Commerce.

The following table gives the quantity and value of all classes of hydraulic cement exported during the years 1900–1916, inclusive,

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and the proportion of exports to the total quantity of hydraulic cement manufactured in the United States. The exports at present consist almost wholly of Portland cement.

Hydraulic cement exported, 1900–1916.[a]

Year.	Quantity (barrels).	Value.	Percentage of total quantity.	Year.	Quantity (barrels).	Value.	Percentage of total quantity.
1900	100,400	$225,306	0.6	1909	1,056,922	$1,417,584	1.6
1901	373,934	679,296	1.9	1910	2,475,957	3,477,081	3.2
1902	340,821	526,471	1.3	1911	3,135,409	4,632,215	3.9
1903	285,463	433,964	.95	1912	4,215,532	6,160,341	5.1
1904	774,940	1,104,086	2.4	1913	2,964,358	4,270,666	3.2
1905	897,686	1,387,906	2.2	1914	2,140,197	3,088,809	2.4
1906	583,299	944,886	1.1	1915	2,565,031	3,361,451	3.0
1907	900,550	1,450,841	1.7	1916	2,563,976	3,828,231	2.8
1908	846,528	1,249,229	1.6				

[a] Statistics compiled from records of Bureau of Foreign and Domestic Commerce, Department of Commerce.

IMPORTS.

The following table shows the quantities of foreign cement imported for consumption into the United States during the years 1878 to 1916, inclusive. Owing to the manner in which statistics of imports are grouped, the quantities given include not only Portland cement but all other hydraulic cements. In recent years, however, most of the total has been Portland cement.

The imports in 1916 were approximately 1,836 barrels, of 380 pounds, valued at $4,942, or about $2.69 a barrel, as compared with 42,218 barrels, valued at $57,174, or about $1.35 a barrel, in 1915. The number of barrels given in the following table is slightly in excess of the true quantity. The imports of cement as reported by the Bureau of Foreign and Domestic Commerce are given in pounds and include the weights of barrels, sacks, and other packages. No data are at hand to show what proportion of the imports are received in barrels or in sacks, though it is understood that the greater part of the material is imported in sacks, which, of course, weigh very little—between 0.5 and 0.6 per cent of the weight of the cement.

The table shows a decline in the imports of foreign cement for the six years ending with 1912, slight increases in 1913 and 1914, and large decreases since 1914, due probably to the cessation of imports from Belgium and Germany.

Foreign cement imported for consumption, 1878–1916, in barrels of 380 pounds.[1]

1878	92,000	1891	2,988,313	1904	968,409
1879	106,000	1892	2,440,654	1905	896,845
1880	187,000	1893	2,674,149	1906	2,273,493
1881	221,000	1894	2,638,107	1907	2,033,438
1882	370,406	1895	2,997,395	1908	842,121
1883	456,418	1896	2,989,597	1909	443,888
1884	585,768	1897	2,090,924	1910	306,863
1885	554,396	1898	1,152,861	1911	164,670
1886	915,255	1899	2,108,388	1912	68,503
1887	1,514,095	1900	2,386,683	1913	85,470
1888	1,835,504	1901	939,330	1914	120,906
1889	1,740,356	1902	1,963,023	1915	42,218
1890	1,940,186	1903	2,251,969	1916	1,836

[1] Statistics compiled from records of Bureau of Foreign and Domestic Commerce, Department of Commerce.

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PORTLAND CEMENT IN CANADA.

The following extract is quoted from the preliminary report on the mineral production in Canada during the calendar year 1916, issued by the Canada Department of Mines, Mines Branch, February, 1917, page 22:

The production of structural materials and clay products which showed a large falling off in both 1914 and 1915, show a further decrease in 1916. The total value of the production in 1916 was $17,301,726, as against $17,920,759 in 1915 and $26,009,227 in 1914.

The total quantity of Portland cement including natural Portland made in 1916 was 4,753,034 barrels of 350 pounds each, as compared with 5,153,767 barrels in 1915, a decrease of 400,733 barrels, or about 7.8 per cent.

The total quantity of Canadian Portland cement sold or used during 1916 was 5,359,050 barrels, valued at $6,529,861, or an average of $1.218 per barrel, as compared with 5,681,032 barrels sold or used in 1915, valued at $6,977,024, or an average of $1.228, showing a decrease of 321,982 barrels, or about 5.7 per cent.

The total imports of cement in 1916 were 72,087 hundredweight, equivalent to 20,595 barrels of 350 pounds each, valued at $31,621, or an average of $1.54 per barrel, as compared with imports of 28,190 barrels, valued at $40,426, or an average of $1.43 per barrel, in 1915.

The total consumption of cement, therefore, neglecting a small export was 5,379,645 barrels, as compared with a consumption of 5,709,222 barrels in 1915, showing a decrease of 329,577 barrels, or about 5.8 per cent.

The average price per barrel at the works in 1916 was $1.218 as compared with $1.228 in 1915, $1.28 in 1914, $1.27 in 1913, $1.28 in 1912, and $1.34 during 1911 and 1910.

The imports of cement in 1916 included 72,083 hundredweight, valued at $31,616, from the United States, and 4 hundredweight, valued at $5, from Great Britain.

CEMENT IN GREAT BRITAIN.

Many inquiries having been received by the United States Geological Survey concerning the cement industry in Great Britain, a request was made that such information as might be obtained by the Department of State on the subject be made available to the Survey. In response to this request the following report was prepared by the consul at London[1] and has already been published.

There are no official statistics giving the production in the United Kingdom of cement for building and engineering purposes since those covering the year 1907. The production in that year, according to the official census, amounted to 2,886,000 tons, valued at $16,779,692. Investigations made among the larger cement producers indicate that the output during the years 1908 to 1913 was approximately 3,000,000 tons annually.

It is estimated that the production during 1914 fell to between 2,220,000 and 2,260,000 tons, but the decline was much greater in 1915 and 1916, in which years the output is estimated at between 1,500,000 to 1,800,000 tons. This is due primarily to war legislation regulating building operations in the United Kingdom during the war.

Before the war the exportation of cement from the United Kingdom was increasing rapidly, but since the outbreak of hostilities this trade has remained about stationary. The export figure, so far as values are concerned, appears to have been maintained, notwithstanding the decrease in production.

In 1913 the exports were valued at $4,963,030, and in 1916 the value was $4,851,998. The quantities, however, show a decrease during the same period of over 200,000 tons. In 1912, 644,575 tons were exported, as compared with only 409,983 tons in 1916. During the past five years 1913 was the most favorable in the cement export trade, when 747,736 tons, valued at $6,195,384, were shipped to foreign countries.

[1] McBride, H. A., British production and exportation of cement: Commerce Reports No. 260, pp. 502–503, Nov. 6, 1917.

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British India has always been the chief destination of British cements, consuming roughly 20 per cent of the total exports. Brazil and Argentina have also taken large quantities, and in 1916 the exports to Brazil even exceeded those to India. Chile, British West Africa, and Australia have also furnished good markets for British cement. The following table shows the exports of cement from the United Kingdom to all destinations, both in quantities and value, since 1912:

Countries of destination.	1912		1913		1914		1916	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
FOREIGN COUNTRIES.								
Argentina	72,136	$546,897	97,670	$798,159	47,631	$390,067	79,307	$920,197
Brazil	83,580	633,190	124,342	990,352	42,701	357,201	68,471	850,960
Chile	22,690	165,232	27,789	221,211	20,459	149,713	35,025	350,188
Egypt	33,392	239,948	17,795	150,867	5,918	45,974	.....	.....
Mexico	3,572	25,973	4,471	36,046	877	8,132	.....	.....
Netherlands	3,638	30,192	4,916	43,307	20,838	169,135	1,304	14,191
Portuguese East Africa	9,733	75,431	8,075	69,630	5,309	46,256	1,421	18,663
Spain	1,037	8,945	13,834	114,178	682	6,161	416	5,913
Turkey	6,786	51,862	3,191	26,766	3,191	27,296	.....	.....
United States	1,315	21,943	1,707	29,574	1,581	25,369	707	16,731
Uruguay	7,916	58,953	6,624	54,826	2,855	22,289	2,503	29,710
Other foreign countries	15,747	150,307	25,852	253,470	28,584	269,585	36,980	481,161
BRITISH POSSESSIONS.								
Channel Islands	4,874	37,569	4,664	39,360	4,292	36,314	1,873	21,651
Australia	42,247	306,444	30,879	234,425	39,274	308,472	10,600	112,913
British East Africa	9,251	79,266	11,964	112,095	13,730	120,402	4,179	52,476
British West Africa	29,285	238,459	35,268	324,776	43,309	374,613	23,931	325,462
British India	112,220	909,802	142,974	1,176,681	142,522	1,164,670	73,806	823,587
British West India Isl'ds	20,342	150,010	16,641	126,179	9,491	72,740	4,983	57,619
Canada	20,833	151,368	8,835	70,165	5,082	44,046	126	2,506
Ceylon	23,422	184,066	25,663	229,129	34,760	298,024	24,329	307,310
Gibraltar	1,071	8,492	2,170	19,850	5,125	41,443	792	9,941
New Zealand	16,268	126,042	6,617	55,731	6,104	52,378	530	13,178
Straits Settlements	31,569	228,998	36,165	288,598	34,628	277,089	7,648	69,586
Union of South Africa	57,705	426,179	65,899	533,665	39,882	330,523	18,605	209,002
Other British possessions	13,946	107,462	23,931	196,344	37,043	306,660	12,456	159,023
	644,575	4,963,030	747,736	6,195,384	595,868	4,944,552	409,983	4,851,998

The quantities of cement imported into the United Kingdom before the war were of some importance. In 1912, 122,331 tons were imported, 97,027 tons of which came from Belgium and most of the remainder from Germany. In 1913, 108,324 tons were imported, with 94,382 tons of Belgian origin. The imports during 1914 amounted to 73,392 tons, and in 1915 to 2,103 tons. In 1916 the imports practically ceased, only 442 tons arriving, 260 tons of which came from the United States.

NATURAL AND PUZZOLAN CEMENTS.

In 1916 only one manufacturer reported an output of puzzolan or slag-lime cement, and in order that this quantity may be comprised in the cement totals for the United States it is included with the statistics of natural cement. The tables showing the statistics of natural and puzzolan cements separately for 1914 and 1915 are also given for purposes of comparison.

The marketed production of natural cement and puzzolan cement in the United States during 1916 amounted to 842,137 barrels, valued at $430,874, as compared with an output of 793,541 barrels, valued at $398,428, in 1915, an increase in 1916 of 48,596 barrels, or 6 per cent, in quantity and of $32,446, or 8 per cent, in value. The average price of these cements per barrel at the mills in 1916 was 51.2

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cents, as compared with 50.2 cents in 1915. In 1915 the average price of natural cement per barrel was 47.8 cents and of puzzolan cement 93.3 cents.

Natural cement was produced in 1915 and 1916 in 12 plants, distributed in seven States, the plants being located at Binnewater (near Rosendale), Jamesville, and Fayetteville (2), N. Y.; Siegfried, Pa.; Lisbon, Ohio (2); Speeds, Ind.; Utica, Ill.; Fort Scott, Kans.; and Austin and Mankato, Minn. The plant at Mankato produces what is called "bricklayer's cement," which is reported to contain more lime than most other kinds of natural cement. The puzzolan cement was made at North Birmingham, Ala. In the following tables the marketed production of natural and puzzolan cements in 1914 and 1915 is outlined separately by groups of States and their combined production is given for 1916:

Natural cement shipped in 1914–15.

State.	1914			1915		
	Producing plants.	Quantity (barrels).	Value.	Producing plants.	Quantity (barrels).	Value.
New York	4	226,737	$111,471	4	229,264	$114,587
Illinois	1			1		
Indiana	1			1		
Ohio	2	258,048	110,974	2	232,099	99,415
Pennsylvania	1			1		
Kansas	1			1		
Minnesota	2	266,500	128,925	2	289,500	144,625
	12	751,285	351,370	12	750,863	358,627

Statistics of the puzzolan cement industry, 1911–1915.

	1911	1912	1913	1914	1915
Number of plants reporting production:					
Alabama	1	1	1	1	1
New York [a]	1	1	1	1	.....
Ohio	1	1	1	1	1
Pennsylvania	1	1	1	1	1
	4	4	4	4	3
Production in barrels	93,230	91,864	107,313	68,311	42,678
Total value	$77,786	$77,363	$97,663	$63,358	$39,801

[a] Includes production of Collos cement, 1911–1914.

Natural and puzzolan cement shipped, 1916.

State.	Producing plants.	Quantity (barrels).	Value.
New York	4	104,415	$51,635
Alabama [a]	1		
Illinois	1	298,596	161,829
Indiana	1		
Kansas	1		
Minnesota	2	315,300	156,400
Ohio	2		
Pennsylvania	1	123,824	61,010
	13	842,137	430,874

[a] Puzzolan only.

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GOVERNMENT AND STATE PUBLICATIONS ON CEMENT MATERIALS, CEMENT, AND CONCRETE.

UNITED STATES GEOLOGICAL SURVEY.

The following list includes the principal publications on cement and concrete materials by the United States Geological Survey. These Survey publications, except those to which a price is affixed, can be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications, except as noted, may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. The Survey does not distribute any other than its own publications.

ADAMS, G. I., and others, Stratigraphy and paleontology of the upper Carboniferous rocks of the Kansas section: Bull. 211, 123 pp., 1903. 20c.

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BALL, S. H., Portland cement materials in eastern Wyoming: Bull. 315, pp. 232–244, 1907. 50c.

BASSLER, R. S., Cement materials of the Valley of Virginia: Bull. 260, pp. 531–544, 1905. 40c.

BASTIN, E. S., The lime industry of Knox County, Maine: Bull. 285, pp. 393–400, 1906. Edition exhausted.

——— Clays of the Penobscot Bay region, Maine: Bull. 285, pp. 428–431, 1906. Edition exhausted.

BRANNER, J. C., Clays of Arkansas: Bull. 351, 247 pp., 1908. 30c.

BURCHARD, E. F., Portland cement materials near Dubuque, Iowa: Bull. 315. pp. 225–231, 1907. 50c.

——— Concrete materials produced in the Chicago district: Bull. 340, pp. 383–410, 1908. 30c.

——— Structural materials available in the vicinity of Austin, Tex.: Bull. 430, pp. 292–316, 1910. 75c.

——— Cement: Mineral Resources U. S. for 1909, pt. 2, pp. 433–452, 1911. 75c; for 1910, pt. 2, pp. 469–535, 1911. $1.25; for 1911, pt. 2, pp. 485–519, 1912. $1.10; for 1912, pt. 2, pp. 503–524, 1913. $1; for 1913, pt. 2, pp. 117–143, 1914. $1.25; for 1914, pt. 2, pp. 221–259, 1916. 80c; for 1915, pt. 2, pp. 189–212, 1917.

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CLAPP, F. G., Limestones of southwestern Pennsylvania: Bull. 249, 52 pp., 1905. 20c.

CRIDER, A. F., Cement resources of northeast Mississippi: Bull. 260, pp. 510–521, 1905. 40c.

——— Geology and mineral resources of Mississippi: Bull. 283, 99 pp., 1906. 15c.

DARTON, N. H., Geology and water resources of the northern portion of the Black Hills and adjoining regions in South Dakota and Wyoming: Prof. Paper 65, 104 pp., 1909. 40c.

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——— Cement materials in Republican Valley, Nebr.: Bull. 430, pp. 381–387, 1910. 75c.

——— and SIEBENTHAL, C. E., Geology and mineral resources of the Laramie Basin, Wyo.: Bull. 364, 81 pp. 1909. 20c.

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DUBYEE, E., Tests of cement materials from Gila River, Ariz.: Water-Supply Paper 33, pp. 82–90, 1900. 15c.

——— Cement investigations in Arizona: Bull. 213, pp. 372–380, 1903. 25c.

ECKEL, E. C., The materials and manufacture of Portland cement: Senate Doc. 19, 58th Cong., 1st sess., pp. 2–11, 1903.

——— Cement-rock deposits of the Lehigh district: Bull. 225, pp. 448–450, 1904. 35c.

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——— The American cement industry: Bull. 260, pp. 496–505, 1905. 40c.
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——— Portland cement materials and industry of the United States, with contributions by E. F. Burchard and others: Bull 522, 401 pp., 1913. 65c.
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FENNEMAN, N. M., Geology and mineral resources of the St. Louis quadrangle, Mo.-Ill.: Bull. 438, 73 pp., 1911. 25c.
GARDNER, J. H., Oolitic limestone at Bowling Green and other places in Kentucky: Bull. 430, pp. 373–378, 1910. 75c.
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——— Organization, equipment, and operation of the structural-materials testing laboratories at St. Louis, Mo.: Bull. 329, 85 pp., 1908. 20c.
——— Portland cement mortars and their constituent materials: Results of tests, 1905 to 1907: Bull. 331, 130 pp., 1908. 25c.
——— The strength of concrete beams; results of tests made at the structural-materials testing laboratories: Bull. 344, 59 pp., 1908. 10c.
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LIPPINCOTT, J. B., Manufacture of Portland cement in southern California: Water-Supply Paper 60, pp. 135–137, 1902. 15c.
MARTIN, G. C., The Niobrara limestone of northern Colorado as a possible source of Portland cement material: Bull. 380, pp. 314–326, 1909. 40c.
PEPPERBERG, L. J., Cement material near Havre, Mont.: Bull. 380, pp. 327–336, 1909. 40c.
RICHARDSON, G. B., Portland cement materials near El Paso, Tex.: Bull. 340, pp. 411–414, 1908. 30c.
RIES, H., Clays of Illinois: Prof. Paper 11, pp. 94–97, 1903. 40c.
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SEWELL, J. S., The effects of the San Francisco earthquake on buildings, engineering structures, and structural materials: Bull. 324, pp. 62–130, 1907. 50c.
SIEBENTHAL, C. E., The Bedford oolitic limestone (Indiana): Nineteenth Ann. Rept., pt. 6 continued, pp. 292–296, 1898. $1.
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STATE GEOLOGICAL SURVEYS.

From time to time investigative work is done by certain of the State geological surveys, and many detailed reports have been published on important local deposits. The surveys of the following States have made special studies of local cement resources: Alabama, Arkansas, California, Georgia, Illinois, Indiana, Iowa, Maryland, Michigan, Mississippi, Missouri, New Jersey, New York, North Dakota, Ohio, Oklahoma, South Dakota, Vermont, Virginia, Washington, and West Virginia. Certain other States have done a little work on their cement materials.

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SMITH, E. A., and ECKEL, E. C., The cement resources of Alabama and the materials and manufacture of Portland cement: Alabama Geol. Survey Bull. 8, 93 pp., 1904.
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ARKANSAS: BRANNER, J. C., On the manufacture of Portland cement: Arkansas Geol. Survey Ann. Rept., 1888, vol. 2, pp. 291–302.
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INDIANA: BEEDE, J. W., Geology of the Bloomington quadrangle: Indiana Dept. Geology and Nat. Res. Thirty-ninth Ann. Rept., pp. 190–312, 1915. (Includes report by G. C. Mance on utilization of by-products of oolitic limestone.)

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ZIRCONIUM AND RARE-EARTH MINERALS.

By WALDEMAR T. SCHALLER.

ZIRCONIUM MINERALS.

ZIRCON.

Two minerals containing zirconium have been produced on a commercial scale—zircon, the silicate of zirconium, and baddeleyite, the oxide of zirconium. Zircon is a colorless to yellow, red, brown, gray, or green mineral, generally in small, well-defined square prisms. It occurs in many rocks, the crystalline limestones and schists, gneiss, granite, pegmatite, and sedimentary rocks. The mineral is very widespread in its occurrence but is found at only a few places in commercial deposits. In North Carolina some of the pegmatites contained enough zircon to warrant their development; at other places only the concentrated sedimentary zircon-sand deposits have been worked.

Zircon contains about 33 per cent of silica and 67 per cent of zirconia, the oxide of zirconium. Iron is a common impurity, but many other elements have been found in zircon, especially in the so-called altered varieties.

BADDELEYITE.

The oxide of zirconium, mineralogically known as baddeleyite (also called brazilite and jacupirangite) has been found in quantity only in Brazil, although it has been identified in Ceylon, Sweden, Italy, and Montana.

In the trade the name baddeleyite seems to be restricted to the variety in distinct crystals, whereas the term brazilite is applied to the fibrous, botryoidal, or columnar forms. The trade name zirkite is used to designate the commercial ore of zirconia, the ore being a mixture of baddeleyite or brazilite, zircon, and a supposed new unnamed silicate of zirconium. Zirkite contains from about 70 to 94 per cent zirconium oxide and the following analyses show how the composition of the commercial ore varies:

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Analyses of zirkite.

	1	2	3	4	5	6	7	8	9	10	11
ZrO_2	93.18	81.75	86.57	85.93	82.00	85.01	71.88	94.12	88.40	74.48	68.93
SiO_2	1.94	15.49	2.50	9.35	11.38	9.63	25.31	2.41	5.89	14.08	26.30
TiO_2	.60	.50	1.43	1.84	.36	1.52	.63	.98	3.12	1.35	.60
Fe_2O_3	2.76	1.06	5.29	1.93	2.08	3.57	.43	3.22	4.07	10.26	3.59
Al_2O_3	.64	.85	1.00	.36	.62	.....	.15	.....	.....	.....	.....
MnO	Trace.	Trace.	.....	.....	.....	.....	.....	.....	.....	.....	.....
H_2O	.47	.63	3.32	1.56	3.35	.....	1.56	.....	.....	.....	.80
	99.68	100.28	100.11	100.97	99.79	99.73	99.96	100.73	101.48	100.17	100.22

1. Slate-gray fava (waterworn pebble resembling a bean). Specific gravity 5.245.
2. Light-brown fava. Specific gravity 4.850.
3–6. Hard lump ore.
7. Gray porous ore.
8. Glassy variety.
9. Stony variety.
10. Pebbles.
11. Commercial variety.

Analyses of purer samples of baddeleyite gave the following results:

Analyses of baddeleyite.

	1	2	3		1	2	3
ZrO_2	97.19	98.90	96.52	MnO	Trace.	.....	.....
SiO_2	.48	.19	.70	MgO	.....	.....	.10
TiO_2	.48	.....	.....	Alkalies	.....	.....	.42
Fe_2O_3	.92	.82	.41	H_2O	.38	.28	.39
Al_2O_3	.40	.....	.43				
CaO	.....	.06	.55		99.85	100.25	99.52

1. Botryoidal, from Brazil. Specific gravity 5.533.
2. From Ceylon. Specific gravity 5.72 to 6.025.
3. From Jacupirangi, Brazil. Specific gravity 5.006.

OCCURRENCE.

UNITED STATES.

The last domestic output of zircon came from the Freeman & Jones mines, near Zirconia, Henderson County, N. C. The zircons were obtained from the decomposed pegmatite. The distribution and occurrence of a zirconiferous sandstone near Ashland, Va., has been described (see bibliography), and, according to report, a production of zircon sand from Florida is expected.

In 1869 a small output of zircon and in 1883 a much larger quantity was reported to have been mined. Small quantities were produced from 1903 to 1907 and then intermittently to 1911. For the last five years no production of zircon in this country has been reported to the United States Geological Survey. In view of the large production of natural zirconium oxide from Brazil it seems doubtful whether for present purposes there will be an active demand for zircon.

BRAZIL.

The following description of the deposits of the natural oxide of zirconium or zirconia in Brazil is by H. C. Meyer.[1] The deposits of zirconia are in the Caldas region, which lies

[1] Meyer, H. C., Brazilian zirkite deposits: Monthly Prices for November, Foote Mineral Co., 1916, pp. 29–31.

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partly in the State of Minas Geraes and partly in the State of Sao Paulo, approximately 130 miles north of the city of Sao Paulo. It is a mountainous plateau, the main elevation of which is about 3,600 feet. The surface is undulating, presenting differences in level of from 300 to 600 feet. The whole area is bounded on all sides by ridges rising abruptly from 600 to 1,200 feet above the general level and forming a roughly elliptical inclosure with a major axis of approximately 20 miles in length and a minor axis of 15 miles. This peculiar arrangement of the higher ridges is very significant when coupled with the fact that the predominant rock of the plateau is a phonolite and the presence of highly mineralized thermal water of considerable medicinal value.

No thorough geological survey has been made of this area with a view to determining the origin of the zirconia. The character of the ore, however, and the formation seems to point to pneumatolitic agencies. A careful study of the relationship of the large masses of coarsely crystalline nephelite-syenite in this area, with pronounced segregations of eudialyte, might throw some light upon this subject.

Zirconia ore can be roughly divided into two classes:

First, alluvial pebbles ranging in size from one-half inch to 3 inches in diameter, generally carrying about 90 per cent to 93 per cent zirconium oxide. These pebbles, known as "favas" and having a specific gravity ranging from 4.8 to 5.2, are found along small stream beds and on the talus slopes of low ridges.

Second, zirconia ore proper, or zirkite, which ranges in shade from a light gray to a blue-black, the lighter colored material carrying a higher percentage of zirconium silicate, as evidenced by analysis, which in some cases shows a minimum of 73 per cent zirconium oxide. The blue-black ore generally carries from 80 per cent to 85 per cent zirconium oxide. By careful sorting, however, a uniform grade carrying about 80 per cent is produced. Prior to the investigations of Derby and Lee, this ore was considered identical with baddeleyite. It has now been shown, however, that it is a mechanical mixture of three minerals; namely, brazilite, zircon, and a new and unnamed zirconium silicate carrying about 75 per cent zirconium oxide. This new mineral has the same crystal form as zircon (67 per cent ZrO_2), but is readily soluble in hydrofluoric acid, while zircon is not affected, this being a characteristic differential test. The finely powdered mineral, on being treated with a weak solution of hydrofluoric acid, leaves a residue of minute, perfect, pyramidal crystals of zircon, the brazilite and new zirconium silicate going into solution. Several large outcrops of the ore occur on the extreme westerly edge of the plateau, one or two isolated boulders weighing as much as 30 tons. No extensive development work has yet been attempted, although several crosscuts have been run to determine the width of the vein, and a few shallow prospect holes to determine the depth, but seemingly, through indifference of the owners, this development work was not completed. Owing to the hardness of the ore, it is almost impossible to drill holes for explosives, and in handling large masses it is found necessary to resort to the primitive methods employed by the emery miners of Naxos. A large fire is built against an exposed face of the ore and kept burning for several hours, at the end of which time water is thrown upon the ore, which produces fracturing of the mass, permitting it to be sledged into pieces easily handled by one man. In some of the deposits the ore occurs in the form of gravel and large pebbles embedded in a reddish clay matrix greatly resembling a boulder clay. This is mined by open cut methods. The clayey mass, on being exposed to the tropical sun and air, readily dries, and the zirconia can then be separated from the clay matrix by a coarse screen. Before shipment, it is thoroughly washed to remove the small percentage of ferruginous matter still adhering.

Most of the mines are many miles from the railroad. Horses for other than saddle purposes are practically unknown, and the ore is transported to the railroad station by ox carts carrying about 1 ton each. These carts are of the most primitive character, having large, solid, wooden wheels some 4 feet in diameter and 6 inches in thickness. From 10 to 15 yoke of oxen (20 to 30 oxen) are generally required for each cart, owing to the mountainous roads.

This very cursory examination of the zirconia deposits makes it unsafe to venture any conjecture as to the quantity of ore available. Suffice it to say, however, that the deposits have been traced for a distance of 15 miles between Cascata and Caldas and, if surface indications are of any significance, are of vast extent.

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USES.

Metallic zirconium has not so far found any practical uses, although several have been suggested. An alloy with iron, ferrozirconium, has found an application in the steel industry. A zirconium steel is said to be particularly suited for armor plates, armor-piercing projectiles, and bullet-proof metal.[1] An alloy consisting of 65 per cent zirconium, 26 per cent iron, 7.7 per cent aluminum, and 0.12 per cent titanium is said to be highly resistant to chemicals, to be malleable, and to make good filaments for incandescent lamps.

The name "cooperite" has been given to a new patented alloy of zirconium and nickel. This new alloy, free from iron and carbon, has a bright silvery luster and is resistant to acids and alkalis. It is stated to be the best known alloy for use in the manufacture of edge tools of all descriptions, mainly machine tools for milling cutters and cast tools for lathe and plane use. Milling cutters and intricate tools of all descriptions may be cast from this alloy in such forms as to require only a minor grinding operation for finishing. Cooperite remains liquid for some time before solidifying, and intricate machine tools can be easily cast from this alloy. The heat conductivity is higher than for other high-speed metals and the cutting efficiency of the tools is therefore increased. The hardness can be varied by changing the proportions of the constitutent metals. An alloy of 2 to 10 per cent zirconium and the remainder nickel is said to take a fine cutting edge. With 16 to 30 per cent zirconium and the remainder nickel or cobalt, the hardness is increased. The melting point and tensile strength are decreased as the proportion of zirconium increases. The addition of molybdenum raises the melting point. It is claimed that cooperite is self-hardening and no tempering or other treatment is necessary except a slight finishing operation.

The incandescence of zirconium oxide, when heated, has led to its use in certain mantles, glowers, and lights. It was first used in the Drummond light to replace lime, and as early as 1830 an attempt was made to use zirconia buttons, heated to incandescence, for lighting the streets of Paris. In 1885 an incandescent gas mantle, composed chiefly of zirconia, was patented, but only a few years later the zirconia was replaced by thoria. About 1900 zirconia was used in the Nernst glower. At present only a very small quantity is used for lighting purposes. The oxide is used as an opacifier in the enamel industry, and small quantities (from 0.1 to 2.5 per cent) have been added to fused silica ware. The oxide makes a nonpoisonous, nondiscoloring white paint of permanency and good covering power, which is not affected by hydrogen sulphide, by acids, or by alkalis. The oxide also finds application in the making of X-ray pictures, and it has also been suggested for use as a polishing powder. Compounds have been used for weighting silk, and the carbide and other compounds, which are very hard, have been suggested as abrasives. Crystals of zircon, when clear and large enough, have been used as

[1] Iron Age, May 3, 1917, p. 1073.

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gem stones, being known as hyacinth when red, jacinth when yellow, and jargon when white. The pale-brown zircons from Ceylon, when decolorized by heat, are known as Matara diamonds.

The chief use of zirconium minerals, at present, is as a refractory material, the linear coefficient of expansion of pure fused zirconia (ZrO_2) being 0.00000084. Material made of fused zirconia can, therefore, be subjected to sudden changes of temperature without breaking. Because of the heat-resisting properties and resistance to fluxes and slags, zirconia would seem to be very suitable material for the manufacture of refractory bricks.

On this subject Meyer[1] says:

In manufacturing refractory ware such as crucibles, muffles, combustion tubes, resistance cores, etc., from zirconia, it must always be borne in mind that the material has a very low thermal conductivity. Hence, the walls of the crucible or other shape must be considerably thinner than would be the case if other refractory bodies were used. Owing to the high tensile strength of articles made from zirconia when properly bonded and burnt at a sufficiently high temperature, it is possible to manufacture such ware without unusual danger of breakage through handling. Another important consideration in the use of zirconia is its resistance to fluxes and slags. Various patents have been secured, both in this country and abroad, covering the manufacture of refractory vessels from zirconia, for which are claimed remarkable heat-resisting properties. In one instance the pure oxide is mixed with 3 per cent to 10 per cent of magnesia, using starch, phosphoric acid, gelatinous zirconium hydroxide, or borates as binders. The ware is fired in an electric furnace at a temperature ranging from 2,000 to 2,300° C., thus producing a body which is practically impervious to all liquids and unaffected by strong acids or alkali fusions. Owing to the extremely low coefficient of expansion, such ware can be subjected to very sudden changes of temperature, in this way resembling fused silica, but, unlike the latter, is not subject to devitrification. Prior to 1915 no extensive research work had been done in America on the production of pure zirconium oxide on a commercial scale, but the inability to secure the product from abroad has spurred American investigators to develop commercial processes, so that there is every promise that an oxide running 98 per cent to 99 per cent ZrO_2 will in time be placed on the market at a price in the neighborhood of 60 cents per pound in ton lots. In the preparation of the pure oxide, it is extremely important that it be practically iron, titania, and silica free. Iron is particularly objectionable, as it acts as a flux. A very high grade commercially pure zirconium oxide gives the following analysis:

ZrO_2	99.91
TiO_2	.04
Fe_2O_3	.01
Al_2O_3	.01
SiO_2	.02
	99.99

A recent European patent covers the use of zirconium oxide as a surfacing material for silica, bauxite, or other refractory bricks and products. It is claimed by this process that a thin layer of zirconium oxide, with a suitable binder, renders the coated article highly resistant to slag corrosion. * * * The proper selection of a binder is a very important consideration in the manufacture of bricks and other ware from zirkite. Phosphoric acid, sodium silicate, and lime were tried but with indifferent success, and in many cases it was clearly apparent that such bonds were absolutely detrimental, causing serious fluxing and softening of the zirkite at comparatively low temperatures. In the manufacture of zirkite bricks in standard shapes, about 5 per cent of a highly refractory clay has been found a satisfactory bond, although a water-ground zirkite has been used as a cementing or bonding material, thus obviating the neces-

[1] Meyer, H. C., The industrial applications of zirconium: Mineral Foote-Notes, Foote Mineral Co., March, 1917, pp. 5–8.

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sity of introducing binder having a lower melting point than the zirkite. American fire-brick manufacturers, however, have been unable to produce zirkite bricks on a commercial scale, owing to their inability to burn them at high enough temperatures to secure the maximum shrinkage. Most attempts to burn these bricks have been made in silica brick kilns, but with indifferent success. The future for zirkite in refractory bricks is very promising. The work along this line has been highly developed on the Continent and actual tests made on a Martin-Siemens furnace using a zirconia-lined hearth, show that after four months of continuous operation at high temperatures, the hearth was still in good condition and would serve at least four months longer before renewal. Careful statistics compiled from these tests show a saving of about 50 per cent in actual maintenance costs in favor of the zirconia lining over an ordinary refractory lining such as is generally used. No allowance was made for increased production and higher efficiency. The initial cost of zirconia lining is rather high as compared, for example, with magnesite brick, but it is more than offset by its higher melting point, marked resistance to corrosion, low thermal conductivity, and low coefficient of expansion.

The investigations of Dr. Charles Morris Johnson during the past few years have resulted in the manufacture of laboratory ware made from zirkite mixed with other refractory bodies. Zirkite filtering crucibles, muffles, combustion tubes, combustion boats, pyrometer protection tubes and Kipp generators with replaceable units are now on the market at prices comparing favorably with like articles manufactured from German porcelain or fused silica. Zirkite combustion tubes have been reported running in steel testing laboratories for as long a period as three months, being used constantly night and day. Owing to the composition of these tubes they are not attacked by basic substances, do not devitrify, and are gas-tight up to temperatures of 1,000° C.

PRODUCTION.

The early output of zircon in Norway and in North Carolina was used in the manufacture of incandescent gas mantles. Thoria and ceria have now entirely replaced zirconia in the manufacture of such mantles. The only zirconium mineral produced in the United States is zircon, almost all of which came from North Carolina. The zirconium minerals produced and exported from Brazil consist of the silicate, zircon, and the oxide, baddeleyite.

Production[a] of zirconium minerals, 1902–1916.

Year.	United States.		Brazil.		Year.	United States.		Brazil.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.		Quantity (short tons).	Value.	Quantity (short tons).	Value.
1902.....	(b)	(b)	12	$3,947	1910.....	0	0	128	$23,271
1903.....	1½	$570	7	1,947	1911.....	[c] 1½	$802	45	16,169
1904.....	¾	200	9	3,935	1912.....	0	0	43	14,772
1905.....	4	1,600	18	5,506	1913.....	0	0	1,119	54,767
1906.....	[c] ½	248	26	5,041	1914.....	0	0	237	14,208
1907.....	(d)	46	38	8,756	1915.....	0	0	8	2,915
1908.....	0	0	275	15,151	1916.....	0	0	104	16,647
1909.....	1	250	117	11,838					

[a] In addition to the quantities and values given in this table, zircon has been produced in very small quantity in different countries, including the United States, because of its value as a gem. The actual figures of production of gem zircon are not available.

[b] It is reported that 1,000 pounds were mined in 1869 and 26 tons in 1883. No value was reported for these quantities. Dr. J. H. Pratt reports a production of 1 ton, valued at $380, in 1902. (Zircon, monazite, and other minerals, etc.: North Carolina Geol. Econ. Survey Bull. 25, p. 19, 1916.)

[c] The exact quantity is 1,100 pounds.

[d] 204 pounds.

[e] The exact quantity is 3,208 pounds.

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RARE-EARTH MINERALS.

INTRODUCTION.

The term "rare earths" is variously interpreted[1] by different authors. As used in this report it excludes thorium and zirconium. A separate report on thorium has been published.[2] The rare-earth elements are cerium, yttrium, lanthanum, neodymium, praseodymium, scandium, dysprosium, europium, samarium, terbium, ytterbium or neoytterbium, lutecium, celtium, erbium, holmium, and thulium. The elemental character of some of these minerals is still in doubt, and a number of additional names, such as victorium and decipium, have been proposed for what the authors believed to be new and additional elements; their chemistry is an exceedingly difficult study; and the status of many of them may undergo considerable revision.

At present only a very few of these rare earths find any practical uses. Industrial chemistry is making such immense strides, however, that it is well not to ignore from the practical side those chemical elements which to-day seem to be only chemical curiosities.

CERIUM.

OCCURRENCE.

Cerium is found in many minerals, the most abundant of which are monazite, allanite, and cerite. Other minerals of very rare occurrence which contain high percentages of cerium are: Beckelith, britholite, caryocerite, erdmannite, freyalite, johnstrupite, melanocerite, mosandrite, rinkite, steenstrupine, thulite, tritomite, tscheffkinite, aeschynite, churchite, rhabdophanite, ancylite, bastnaesite, cordylite, parisite, weibyeite, fluocerite, tysonite, yttrocerite, samarskite, fergusonite, and euxenite. When the industrial uses of cerium were discovered a demand for allanite arose, and a large deposit of this mineral was found in Virginia. The mineral monazite, however, is more abundant than all the others combined, and, as thousands of tons of monazite are mined annually, it seems that the value of any deposit of minerals, considered solely on its cerium content, is very doubtful and will remain doubtful for a long time to come.

Monazite[2] is mined for its content of thorium which is the basis of the incandescent gas mantles; the cerium and other rare earths in monazite are by-products obtained in large quantities. The total output of monazite which has been mined in the world to date is about 88,000 tons. About a quarter of this is ceria, the oxide of cerium, so that it is evident that a very large supply of ceria is already on the market. The rare earth residues obtained from monazite in the process of extracting the thoria consist of about 45 per cent ceria, 25 per cent lanthania, 15 per cent didymia, the remainder being composed chiefly of yttria and samaria.

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[1] The term "earth" is applied to certain metallic oxides which were formerly regarded as elementary bodies, as Y_2O_3, Er_2O_3, La_2O_3, and names ending in "a" are often used in designating them, as yttria, erbia, lanthana. The ending "um" designates the element, as yttrium, erbium, lanthanum. (Browning, P. E., Introduction to the rarer elements, 2d ed., p. 35, 1908.)

[2] Schaller, W. T., The production of thorium minerals in 1916: U. S. Geol. Survey Mineral Resources, 1916, pt. 2, pp. 223–237, 1917.

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USES.

Cerium finds a number of applications, but the total quantity consumed is only a small fraction of the total quantity produced. The incandescent mantles contain about 1 per cent ceria, as it has been found that a mixture of 99 parts of thoria and 1 part of ceria gives the brightest illumination.

The metals of the cerium group (cerium, lanthanum, neodymium, and praseodymium) when scratched throw off glowing particles. This property is not lost in alloys, and as the cerium metals are too soft to be used alone they are alloyed with harder and commoner metals such as iron, tin, and zinc. These alloys possess the necessary strength, hardness, and brittleness to permit of their use in lighting devices. These alloys with the cerium metals have been given various names, such as pyrophoric alloy, spark-giving alloy, cer, lanthan, ferrocerium, cerium alloy, cerium-iron alloy, cerium mixed metal, sparking metal, ignition stone, firestone, erd-metal, misch-metal, and Auer metal. One brand of cerium mixed metal consists of approximately 50 per cent of cerium, 45 per cent of lanthanum, neodymium, and praseodymium, and 1 per cent of iron. Another alloy contains 71.2 per cent cerium, 27.8 per cent other rare earths, 0.43 per cent iron, and 0.38 per cent silicon. These mixed metals are alloyed with iron before use. By scratching these alloys with hardened steel sparks are given off which will ignite tinder or a wick wet with alcohol or benzine. The sparks are caused by the fact that the metal cerium ignites at a low temperature. When such alloys are scratched small pieces of the metal are broken off and the heat of the friction raises these minute particles to the ignition temperature when they burn, uniting with the oxygen in the air to form the oxide of cerium. Recently it has been suggested that the chemistry of the process is more complex, a layer of suboxide, itself pyrophoric, being formed on the metal. The igniting property of these sparks has been applied to cigarette lighters and to various forms of gas lighters. Their use has also been suggested for the ignition of explosives, in military signaling, and as an illuminant in photography. Various combinations of the elements have been suggested for use as electrodes in arc lamps and flash-light powders. These alloys have been suggested as reducing agents, and the addition of 0.2 per cent of cerium to metallic aluminum is said to have a beneficial effect on its properties.

Salts of cerium find an application as catalysts in the manufacture of aniline black and have been proposed for use as a catalyst in the contact process for the manufacture of sulphuric acid. The oxidizing powers of cerium salts have been applied to the manufacture of a number of organic substances. Cerium sulphate has been employed in photography for removing silver from overdeveloped negatives; cerium salts are used in color photography; and the oxalate finds a very slight use in medicine.

Attempts have also been made to use cerium salts for tanning and dyeing and in the manufacture of certain enamels, glasses, and porcelains.

YTTRIUM.

OCCURRENCE.

The chief sources of yttrium compounds are the minerals gadolinite and xenotime. The residues from the thorium extractions from

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monazite also contain yttrium. Other minerals containing yttrium in quantity are: Allanite, cappelenite, cenosite, rowlandite, thalenite, yttrialite, fergusonite, euxenite, samarskite, polycrase, rogersite, sipylite, yttrocrasite, yttrotantalite, tengerite, and yttrocerite. The elements erbium, terbium, holmium, thulium, dysprosium, ytterbium, lutecium, and europium belong in the same chemical group as yttrium.

The largest deposit of yttrium minerals known in this country is in Llano County, Tex.,[1] which has produced about a ton or more of yttrium minerals. About 1,200 pounds of gadolinite was produced[2] in Norway in 1905–6.

USES.

At present the elements of the yttrium group have very little technical importance. They were formerly used in the manufacture of filaments for Nernst lamps, but metal-filament lamps have now largely superseded them. Thulium oxide is said to emit a carmine-colored light when heated to a certain temperature. The oxide of terbium is a strong catalyzer and may be used as a contact agent in oxidation processes.

The present demand for these elements seems to be so small that no encouragement is held out for the development of deposits of yttrium minerals.

Gadolinite is reported[3] to have been gathered from the sand dunes in Mohave County, Ariz., by the thousands of pounds for use as a gem stone.

LANTHANUM.

OCCURRENCE.

Lanthanum and the two elements neodymium and praseodymium, which together are sometimes called didymium, form an essential part of the mineral monazite. As with cerium, the large quantities of oxides of the lanthanum group, obtained as a by-product in the extraction of thorium from monazite, would suffice to supply a considerable demand. Three other elements, samarium, scandium, and decipium belong in the lanthanum group. These elements are widespread in their occurrence and, like most of the rare earths, are found in small quantities in many minerals. Browning[4] lists 200 names of minerals containing rare earths.

In addition to monazite the minerals cerite, allanite, bastnaesite, and lanthanite are sources of lanthanum; cerite, allanite, and bastnaesite of neodymium and praseodymium; samarskite, allanite, cerite, gadolinite, and keilhauite of samarium; gadolinite, yttrotitanite, euxenite, and keilhauite of scandium; and samarskite of decipium.

USES.

A solution of the nitrates of neodymium and praseodymium are used for marking the incandescent gas mantles. An organic dye,

[1] Hess, F. L., Minerals of the rare-earth metals at Baringer Hill, Llano County, Tex.: U. S. Geol. Survey Bull. 340, pp. 286–294, 1908.

[2] Brögger, W. C., Die Mineralien d. Süd-Norweg. Granit-pegmatit gänge. I. Niobate, Tantalate, Titanate und Titanoniobate: Videnskabs-Selskabets Skrifter, Math.-naturv. Kl., No. 5, p. 20, 1906.

[3] Schrader, F. C., Stone, R. W., and Sanford, Samuel, Useful minerals of the United States: U. S. Geol. Surv. Bull. 624, p. 28, 1917.

[4] Browning, P. E., Introduction to the rarer elements, 2d ed., pp. 36–42, 1908.

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such as methylene blue, is added to make a visible impression on the mantle, as the solution of the nitrates is only faintly colored. On ignition, the organic dye is destroyed and the nitrates are converted to the oxides, which are deeply colored and permanent.

Lanthanum, like cerium, is pyrophoric and emits sparks when scratched. As stated under cerium, some of the pyrophoric iron alloys contain much lanthanum and other elements of this group.

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BORAX.

By CHARLES G. YALE and HOYT S. GALE.

PRODUCTION.

In 1916 the production of crude borate material in the United States was 103,525 short tons, valued at $2,409,459, compared with 67,003 short tons, valued at $1,677,099, in 1915, and 62,400 short tons, valued at $1,464,400, in 1914. All the crude borate material now used in this country is the mineral colemanite (calcium borate), and the output in 1916 came from a few mines in southern and southeastern California. The value of the product given is the value of the ore at the point of shipment estimated on a basis of $1 per unit (per cent) of anhydrous boric acid (boron trioxide, B_2O_3) in the raw material. All the ore shipped from California, however, was calcined or concentrated before being put on the cars at the mines.

A statement of the production of borax and borate materials in the United States (altogether from California and Nevada), compiled from the most authentic sources available, is given below:

Borate materials produced in the United States, 1864–1916.

Year.	Crude (short tons).	Refined (short tons).	Value.	Year.	Crude (short tons).	Refined (short tons).	Value.
1864		12	$9,478	1892		6,750	$900,000
1865		125	94,099	1893		4,350	652,425
1866		201	132,538	1894		7,340	974,445
1867		220	156,137	1895		5,959	595,900
1868		32	22,384	1896		6,754	675,400
1869		0	0	1897		8,000	1,080,000
1870		0	0	1898		8,000	1,120,000
1871		0	0	1899		20,357	1,139,882
1872		140	89,000	1900	24,235	1,602	1,018,251
1873		1,000	496,000	1901	17,887	5,344	1,012,118
1874		2,000	567,000	1902	2,600	17,404	2,538,614
1875		2,717	672,000	1903	34,430		661,400
1876		2,590	563,000	1904	45,647		698,810
1877		1,864	364,000	1905	46,334		1,019,154
1878		1,401	249,000	1906	58,173		1,182,410
1879		792	143,000	1907	52,850		1,121,520
1880		1,846	277,233	1908	25,000		975,000
1881		2,023	304,461	1909	41,434		1,534,365
1882		2,118	338,903	1910	42,357		1,201,842
1883		3,250	585,000	1911	53,330		1,569,151
1884		3,500	490,000	1912	42,315		1,127,813
1885		4,000	480,000	1913	58,051		1,491,530
1886		4,889	488,915	1914	62,400		1,464,400
1887		5,500	550,000	1915	67,003		1,677,099
1888		3,795	455,340	1916	103,525		2,409,459
1889		4,000	500,000				
1890		4,750	617,500		777,571	151,315	39,355,676
1891		6,690	869,700				

NOTE.—Prior to production from Nevada, prices ranged from 28 to 35 cents a pound for the refined borax extracted from the California lake waters. After 1872 the price dropped during the next two years to 6½ cents a pound; it then advanced slowly to 11 to 13 cents, but again fell off. In 1885 borax sold in San Francisco for 6 to 8 cents a pound; a further decline followed. From 1882 to 1903, inclusive, the refined product was used as a basis for estimating the value; but since 1904 the value has been estimated on a basis of unit values assigned to the boric acid in the crude product.

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SOURCES OF DOMESTIC BORAX.

Domestic borax continues to be derived entirely from California colemanite ores. The famous Lila C. mine of the Pacific Borax Co., in the mountains of the Death Valley region of Inyo County, after making a final small output early in 1915, was abandoned, and the company has since confined its efforts mainly to the Biddy McCarty and Widow mines, two properties opened and made productive in 1915. A small production, amounting in all to only a few hundred tons, was made from the old mines at Daggett, but this was considered merely as cleaning out these former workings. At the Lang property of the Sterling Borax Co., in Los Angeles County, new deposits have been opened. The Stauffer Chemical Co., of San Francisco, did not make any production at the Russell borate mines, in Ventura County, in 1916. The other properties in Ventura County were also unproductive, owing it is supposed to lack of transportation facilities.

There is still considerable activity in the exploration for new deposits and in the reexamination of old properties that might be made productive again, especially under the present increasing prices for borax and boric acid.

Probably the largest single exploration of the year was that conducted by F. M. Smith, of Oakland, Cal., at Cave Springs, Nev. The existence of deposits containing borate or boron-bearing material in the volcanic hills bordering some of the Nevada borax marshes has been known for many years. The material is unlike anything that has ever been worked for borax, being a bedded deposit like clay or volcanic ash. Considerable work has been done in development of the deposit near Cave Springs, which is about 25 miles west of Goldfield on the road to Fish Lake Valley. Samples submitted to the United States Geological Survey were examined microscopically by E. S. Larsen and found to contain a material corresponding in its optical properties to the recently described mineral searlesite, which is a sodium boro-silicate.

A considerable production of potash salts containing a good deal of borax is being made at Searles Lake, Cal., but the borax is not yet being separated or refined, and, as no use of the borate is made, no account is taken of this material in the returns for 1916.

The location of the western borax deposits is shown in Plate III.

BORAX AND BORIC ACID.

The principal compounds derived from the crude borate minerals by processes of manufacture are borax and boric acid, and practically the entire consumption of this material is represented by these two salts. Of these borax is produced in larger quantity than boric acid.

Borax, technically sodium tetraborate ($Na_2B_4O_7.10H_2O$), consists of boron trioxide or anhydrous boric acid (B_2O_3) 36.6 per cent, soda (Na_2O) 16.2 per cent, and water (H_2O) 47.2 per cent.

Anhydrous borax ($Na_2B_4O_7$) may be obtained by heating the borax crystals to drive off the water of crystallization, and consists of boron trioxide or anhydrous boric acid (B_2O_3) 69.3 per cent and soda (Na_2O) 30.7 per cent.

Boric acid (sometimes called also boracic acid) (H_3BO_3) consists of boron trioxide or anhydrous boric acid (B_2O_3) 56.5 per cent, and water (H_2O) 43.5 per cent.

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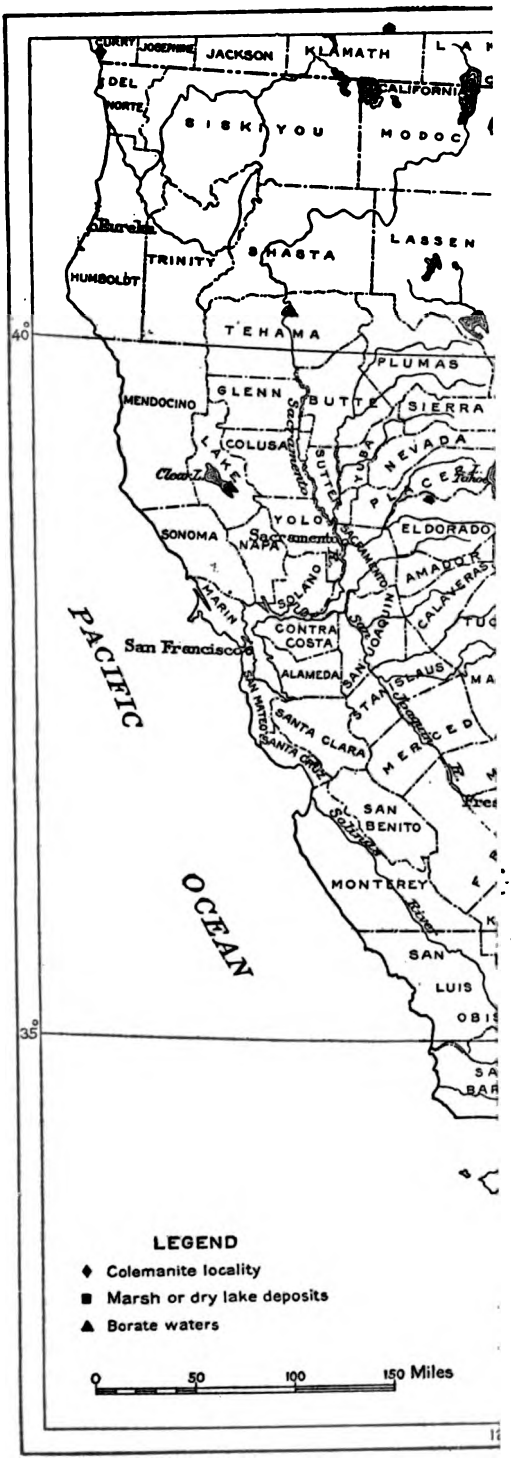

MAP SHOWING BORAX DE

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Anhydrous boric acid (B_2O_3), commercially designated "A. B. A.," is the common standard by which the boron or boric acid content of the crude mineral or of the refined salts is stated.

USES OF BORAX AND BORIC ACID.

The greater part of the borax consumed in this country is used in the manufacture of enamels or porcelainlike coatings for metal utensils, such as bathtubs, kitchen sinks, cooking utensils, and the like. Fully one-third of the normal production is used in this way. Almost a third of the combined production of borax and boric acid is used by manufacturers of other chemicals. Both borax and boric acid are dispensed through wholesale and retail druggists and dealers that supply the domestic requirements, and these uses account for 25 per cent or more of the whole production. The remaining 10 per cent to be accounted for is distributed among meat and fish packers, manufacturers of glass, tanners, soap manufacturers, and potters.

The figures concerning these uses have been compiled in some detail by the manufacturers of borax and boric acid, but unfortunately the tabulations happen to be given in forms which can not be compiled into a single table, and the tabulations themselves are confidential.

PRICES OF BORAX AND BORIC ACID.

Price quotations given in the trade journals show a gradual rise in the price of borax and boric acid, reaching about 7 or 8 cents a pound for borax and about 12 cents a pound for boric acid toward the close of 1916. It is understood that contracts for large quantities of borax were placed during the year at 5¾ cents a pound and that contracts for 1917 delivery were at 6¾ cents a pound.

IMPORTS.

Borax and borates imported for consumption in the United States, 1902–1916.

Year.	Borax.		Borates, calcium and sodium (crude) and refined sodium borate.		Boric acid.	
	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.
1902	684,537	$20,795	186,807	$12,002	822,907	$30,439
1903	68,978	5,727	146,654	13,280	693,619	28,011
1904	153,952	10,569	89,447	6,630	708,815	27,658
1905	166,960	8,802	20,395	1,626	676,105	22,372
1906	791,425	27,343	57,711	2,436	986,021	33,200
1907	2,268,065	77,258	2,959	175	534,524	23,547
1908	641,632	22,058	40	4	385,064	14,702
1909	7,124	1,023	20,284	1,956	265,985	8,708
1910	6,860	1,170	563	66	336,466	11,164
1911	9,582	732	28,815	5,230	458,900	17,666
1912	9,280	636	16,091	1,861	232,545	8,752
1913	4,215	477	7,900	1,025	423,215	16,932
1914	220	29	3,862	546	425,241	18,837
1915	.....	.....	2,748	393	442,073	20,888
1916	83	3	703	135	354,710	19,905

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MAGNESITE.

By CHARLES G. YALE and HOYT S. GALE.

GENERAL CONDITIONS.

The production of magnesite in the United States in 1916 far exceeded that of any preceding year. The increase was due to the larger demand for refractory magnesite products and to the decline in imports. Though more magnesite was used in the United States in 1916 than in 1915, the consumption was less than that of any of the three years preceding 1915, and the use of the mineral has now been greatly curtailed by its relative scarcity and high cost. Owing to its use in the steel and copper industries magnesite is an important though a minor war commodity, and the need for it in these industries is so great that its lack has at times been viewed with serious apprehension.

Magnesite produced in and imported into the United States, 1912–1916, in short tons.

Year.	Domestic production, raw.	Imports "for consumption."		Total consumption calculated as calcined.
		Raw.	Calcined.	
1912	10,512	17,905	125,252	139,460
1913	9,632	13,240	167,094	178,530
1914	11,293	13,354	121,817	134,140
1915	30,499	49,765	26,574	66,706
1916	[a] 154,974	75,345	9,270	124,430

[a] The figures for production in 1916 have been revised since the publication of the preliminary statement in U. S. Geol. Survey Bull. 666-BB.

The properties that made the largest production in 1916 are in Tulare County, Cal., though considerable quantities were produced also in Santa Clara, Sonoma, Napa, Kern, and Fresno counties, Cal., and from deposits recently opened in Stevens County, in eastern Washington.

The data given above show that 1914 was the last year in which the imports were approximately normal. About 90 per cent of these imports were received from Austria and Hungary, and almost all the rest came directly or indirectly from Greece. The European war at first cut off the shipments from the Austrian and Hungarian deposits, so that for a time the imports of the purer Grecian magnesite greatly increased. Later the lack of boats and the dangers of navigation cut off a large part of the Grecian supplies and stimulated

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the development of the domestic deposits. In 1915 only 11,000 tons of Austrian magnesite was imported, but the shortage of the supply from Austria was in part replaced by Grecian material and by 2,500 tons of calcined magnesite obtained from Canada. In 1916 the larger part of the imported calcined magnesite came from Greece, although about 2,000 tons was received from Canada. Most of the imported magnesite has come through the port of Philadelphia, but some has come by way of New York and New Orleans, and a small quantity by way of San Diego, Cal.

The most important development of the year 1916 was the opening in eastern Washington of large deposits of a coarsely crystalline magnesite that is like marble or dolomite in texture but is essentially magnesite in composition. Early in 1917 this material was being shipped at the rate of several hundred tons a day, and calcining furnaces were in course of erection to prepare magnesia for use in making refractory material and, it is said, also for use in cement mixtures. Coming at a time when the sources of supplies abroad are cut off, the discovery of these deposits appears to be most fortunate. The deposits are large and it appears that they will afford a supply of uniform character by relatively cheap methods of mining. It is perhaps too soon to say just how well the material is suited for refractory or other uses, but the present indications are that it is proving to be very satisfactory.

The other large deposits in this country are in California, where the material, like the Grecian, occurs in serpentine rock and has ordinarily not been favored for use in furnaces. One deposit in Sonoma County, Cal., is of the serpentine type, containing iron as an impurity, and is now utilized in the manufacture of refractory bricks. The cost of mining and of transportation from the Western to the Eastern States, where most of the refractory materials are handled and used, is greater than the cost of mining and of shipping by water from abroad, and this has been the principal fact prohibiting the production of domestic magnesite other than the small quantity used on the west coast, chiefly in the manufacture of paper. Now the higher price paid for magnesite has induced the development of many properties that have hitherto been little worked.

The prices paid in California for the raw ore at the mine or shipping point ranged from $8 to $10 a ton, but though much was shipped raw, a part of the product was calcined at the mine. The eastern users had to pay, in addition to the original price, heavy charges for transporation, amounting to about $10 a ton. Thus raw magnesite cost the eastern users not less than $18 to $20 a ton, and the added expense of calcining and the resulting loss of weight made the minimum cost, even to large users, very much higher than formerly. However, even at these high prices the demand for magnesite is very great.

Most of the refractory magnesite formerly in general use has peculiar and distinctive properties that are not found in the magnesite deposits of the California type. The value of this refractory material depends not only on its resistance to the corrosive action of heat and metallic slags, but also on the permanence of the forms in which it is put into the furnace. This permanence is due to a natural bonding which tends to make the loose crushed material cling to-

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gether under furnace heat and thus makes brick forms molded from it more durable. Bricks and granular furnace bottoms made of magnesite that lacks this bond break, and the magnesite floats off on the fluid molten metal and is lost in the slag. Thus, though magnesite that contains a small percentage of iron may be somewhat less resistant to extreme heat than a purer form, the slight fusibility given to the material by the iron tends to hold it in place. For this reason, in part, a type of magnesite so far found only in Austria and Hungary has been the principal source of the refractory magnesia used in this country. The purer magnesite from Greece, California, and elsewhere is used in making plaster or cement or material for other relatively minor uses.

Magnesite is reduced to magnesia either in "dead-burned" or sintered form, or in what is known as "caustic calcined" form. Dead-burned or sintered magnesite has been so strongly heated that essentially all its carbon dioxide and moisture have been driven off and most of the shrinkage taken up. In this condition it is chemically very inert—that is, it is not subject to attack or disintegration even under extreme heat. The caustic form is not so thoroughly calcined; it still retains 1 or 2 per cent of carbon dioxide and is thus a product more like ordinary caustic lime in its properties, although not so active chemically. Caustic magnesite "slacks" slowly when exposed to the air, recombining with moisture and carbon dioxide. Combined with calcium chloride it forms a distinctive cement known as Sorel or oxychloride cement, which is much favored by builders for floors and other places where special finish is desired. This is probably the most important use to which pure caustic calcined magnesite is put, although it is used also for making liquors in which wood pulp is digested to make paper, as well as for other purposes.

It is difficult to determine just how much magnesite was formerly used in the various industries, as for instance in making steel, for copper furnaces, for laying cement flooring, in making paper, and for other purposes. The greatest part of the magnesite used goes for the manufacture of steel and copper. It has been estimated that about 6 pounds of calcined magnesite was formerly used for each ton of steel made by the basic open-hearth process. Although the production of open-hearth steel has steadily increased during recent years, the consumption of magnesite has fallen off to such an extent that it is quite clear that the ratio of magnesite used per ton of steel produced is very much less than it formely was. The magnesite-cement flooring trade in the United States is an important industry, though the high price of caustic calcined magnesite and the uncertain quality of the material supplied from some sources have undoubtedly greatly restricted its use in cements. The making from magnesite of digestion liquors for the paper industry is confined chiefly to companies on the Pacific coast, which have depended on the supply from California deposits. Now that magnesite is so much needed in metallurgic industries and that its value has increased so much, it is possible that some of the magnesite used in making paper may be replaced by dolomite or other cheaper materials, especially in view of the availability of dolomite in place of magnesite at a considerably lower cost.

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PRODUCTION.

The crude magnesite produced and sold or treated in the United States in 1916 amounted to 154,974 short tons, valued at $1,393,693, as compared with 30,499 tons, valued at $274,491, in 1915. In 1916 California produced 154,259 tons, valued at $1,388,331, and Washington 715 tons, valued at $5,362.

Crude magnesite produced and sold or treated in the United States in 1916.

	Quantity (short tons).	Value.		Quantity. (short tons).	Value.
California:			California—Continued.		
Alameda	2,500	.....	Stanislaus	15	.....
Fresno	5,260	.....	Tulare	87,423	.....
Kern	7,685	.....	Tuolumne	80	.....
Mendocino	306	.....		154,259	$1,388,331
Merced	90	.....	Washington:		
Napa	13,960	.....	Stevens	715	5,362
Placer	340	.....		154,974	1,393,693
Riverside	600	.....			
Santa Clara	23,400	.....			
Sonoma	12,600	.....			

Crude magnesite produced in the United States, 1891–1916.

	Quantity (short tons).	Value.		Quantity (short tons).	Value.
1891	439	$4,390	1904	2,850	$9,298
1892	1,004	10,040	1905	3,933	15,221
1893	704	7,040	1906	7,805	23,415
1894	1,440	10,240	1907	7,561	22,683
1895	2,220	17,000	1908	6,587	19,761
1896	1,500	11,000	1909	9,465	37,860
1897	1,143	13,671	1910	12,443	74,658
1898	1,263	19,075	1911	9,375	75,000
1899	1,280	18,480	1912	10,512	84,096
1900	2,252	19,333	1913	9,632	77,056
1901	3,500	10,500	1914	11,293	124,223
1902	2,830	8,490	1915	30,499	274,491
1903	3,744	10,595	1916	154,974	1,393,693

DEVELOPMENT.

CALIFORNIA.

The production in California has followed lines previously discussed in some detail in reports of the United States Geological Survey. Deposits of magnesite associated with serpentine occur in many places throughout California, and some of the deposits are large. Continued high prices and the readiness under stress and demand of war to pay the high freight from California to eastern markets has stimulated production from large and small deposits, so that there have been many producers during 1916.

The ore in serpentine is variable, some of it containing a high percentage of silica, which has caused some dissatisfaction with the material produced. As deposits in serpentine are pockety and irregular, it is not now known how long the California supply will last under the present heavy drain, but four or five large deposits of high-grade material are known which can not soon be exhausted.

Alameda County.—The only productive magnesite mine in Alameda County in 1916 was that on Cedar Mountain, from which some

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shipments were made. The Livermore Fire Brick Co. did some prospecting on its claim during the year but made no output.

Fresno County.—The producing mines in Fresno County are at or near Piedra and were the Ward, Levensaler-Speir, and Hughes Creek. The Fresno Magnesite Co. (now dissolved) performed development work only, with no output. Since the end of the year this mine has been sold and the new owners have increased the calcining capacity.

Kern County.—The Rex Plaster Co. continued to work the deposit leased from the Southern Pacific Co., near Bissell, in this county; and the same company also operated a magnesite mine near Porterville. In November, 1916, the calcining plant of this company, at San Pedro, Los Angeles County, was destroyed by fire.

Mendocino County.—Two properties near Willits made small shipments of ore in 1916, but were mined out and closed down permanently before the end of the year.

Merced County.—Both the Manzanita and the Bald Eagle mines, near Gustine, made small shipments of crude ore, but no furnaces were operated in Merced County in 1916. Shipments from this county have materially increased since the end of 1916, other mines having been opened.

Napa County.—During 1916 the old Blanco mine at Chiles Valley, which had been virtually abandoned for some years, was purchased and reopened by the Tulare Mining Co., and extensive shipments of crude ore were made. The White Rock mine, in Pope Valley, produced largely, and after the end of the year eight calcining kilns were put in operation. The old Matthai mine in Chiles Valley, operated by George W. Elder, made a considerable output. A small yield was obtained from the property of the Minerals Development Co., 16 miles east of Rutherford. A nominal output was made from the Bulski lease, in Chiles Valley.

Placer County.—A few hundred tons of crude ore was shipped from "prospects" at Towle and Alta stations, on the Southern Pacific Railroad.

Riverside County.—The mines of the Magnesco Refractories Co., at Winchester, made only a nominal output in 1916.

Santa Clara County.—The largest producer in this county was the Western Magnesite Development Co., at Red Mountain. In the summer of 1916 this company operated 42 autotrucks hauling calcined and crude ore 32 miles to the railroad at Livermore. There are two vertical calcining kilns at the mine. A small quantity was also produced by the Pacific Magnesite Co., in the same region. Lessees on the several properties of the Bay Cities Water Co., near Madrone, also made some output. A small quantity of ore was derived from the ranch of H. S. Bradford, near Evergreen.

Sonoma County.—The Sonoma Magnesite Co. owns the most productive mine in this county, where a railroad and rotary calciner have been installed. The mine is near Cazadero, and both calcined and raw ores were shipped. The Refractory Magnesite Co., near Preston, has a vertical kiln and shipped only calcined material in 1916. This company has ore carrying sufficient iron to make it suitable for the manufacture of refractory bricks. The ore was all dead burned and shipped to Stockton, where it was made into refractory bricks. These bricks are in use at the Selby Smelting &

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Lead Co.'s plant on San Francisco Bay, and also in furnaces at Salt Lake City. A small quantity of ore was produced by the Sotoyome Magnesite Co., of Healdsburg; and the Farish Co., near Cazadero, also made a small output. A few hundred tons were also produced by the Alberz mine, near Cloverdale. After taking out several thousand tons of ore from the Yordi (or Melville) ranch, near Cloverdale, the mine was considered worked out and closed down. In 1917 this deposit was reopened by underground work and continued to produce ore. The Gilliam Creek deposit made no output in 1916, but in 1917 a kiln was built at Guerneville and ore from the mine was hauled to it for calcining. A number of small deposits are known in this county upon which little or no work has been done.

Stanislaus County.—Only a nominal quantity of magnesite was produced in Stanislaus County in 1916, but since the end of the year some properties carrying exceptionally high-grade ore have been developed and are producing.

Tulare County.—The most productive magnesite mines in California are in Tulare County and also the largest number of operating properties. The Tulare Mining Co., which is working deposits on South Fork of Tule River, east of Porterville, was a pioneer in the magnesite business in the State and still continues to make a large annual output. Most of the output is used in the manufacture of paper from wood pulp, but some of it is calcined, ground, and sold in San Francisco to manufacturers of flooring and tiling, and it is also shipped east in quantity by rail in bulk. The calcining capacity of the company has been increased since the end of the year. The Porterville Magnesite Co., of California, owning the old Harker property, at Porterville, has now become one of the larger magnesite producers in the State. Most of the output is shipped from the mine in crude form, but some hundreds of tons were calcined in the rotary furnace erected in May, 1916. A large quantity was also shipped to the Pure Carbonic Co. at Berkeley, where it was calcined for the Hawley Paper & Pulp Co., of Oregon. Materially enlarged calcining facilities were installed at the mine after the end of the year. The Rex Plaster Co., of Los Angeles, which is operating the deposit at Bissell, Kern County, is also working a magnesite mine near Porterville, purchased during the year. Only a portion of the output was calcined. The ore from the Avery mine, under lease to the Rex Plaster Co., was all shipped crude, as was that from the Coghlan mine. The output of the Pure Carbonic Co. was all calcined and shipped to the Hawley Paper & Pulp Co., in Oregon. A new deposit was also purchased and opened by this company. Considerable ore was shipped east by Langley & Cook, of Porterville, and after the end of the year their mine was sold to the Oakland Magnesite Co., of Oakland, Cal. The California Magnesite Co., owning a lease on the Vaughn ranch, 4 miles from Porterville, produced a few thousand tons, and the property was later sold to the International Magnesite Co., of Los Angeles. In the vicinity of Porterville Baggs & Davis and H. M. Hathaway shipped a few thousand tons crude from their deposits. The Lindsay Mining Co. commenced producing in 1916 and made large shipments of crude ore during the year; none of it was calcined. The Burr Bros. and Wood & Hyde made shipments of ore from Lindsay to the Eastern States. Production at Dinuba was

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made by the Dinuba Magnesite Co., and a large quantity of its ore was shipped to the custom calcining plant at Berkeley, where it was calcined for the Hawley Paper & Pulp Co., of Oregon. The Mitchell Association at Dinuba made some output, and a few thousand tons came from the Joyner mine, at Exeter. In Terra Bella district, 12 miles southeast of Porterville, there were a number of small producers in 1916, the aggregate shipments being about 1,500 tons. The Magnesite Mining Co., in developing a mine on the property of G. W. Stewart in Frazier Valley, just east of Porterville, made a small output and then sold the property to the Magnesite Refractories Co. On numerous ranches, farms, and orchards in this county small isolated deposits of magnesite have been found, which have been prospected and worked by nomadic miners or farm laborers under lease or royalty. Most of this output has not exceeded 50 to 100 tons in individual lots, which have been sold crude to the larger companies or dealers in the mineral at Porterville, Exeter, Dinuba, Lindsay, and other points on the railroad line.

Tuolumne County.—The Minerals Development Co., of San Francisco, opened a new deposit of magnesite near Chinese, in Tuolumne County, and made small shipments to a calcining plant at West Berkeley, Alameda County.

WASHINGTON.

The most important development of magnesite in 1916 was the discovery and opening of extensive deposits in Stevens County, Wash. These deposits have been found at several localities west of Valley and southwest of Chewelah, stations on the Great Northern Railway about 60 miles north of Spokane. The Washington magnesite is very different in character from that of the California deposits and occurs in larger and more massive deposits. It is coarsely crystalline, like marble or coarse-textured dolomite; in fact, one of the properties was first exploited some years ago as a source of marble. Probably the first published statement of the magnesium character of the material is that made in the second annual report of the Washington Geological Survey in 1903. In a paper on building stones by Shedd,[1] the marble-quarrying industry near Valley, Stevens County, is described, and an analysis is given of dark coarsely crystalline limestone from the United States Marble Co.'s quarry, which shows 42.07 per cent magnesia and 47.23 per cent carbon dioxid, with the following comment: "As shown by the accompanying chemical analysis this is almost a pure magnesian carbonate and has very much the same composition as magnesite, but it differs from most magnesite in the fact that it is crystalline." Analyses are given of samples from other properties in the vicinity, and the comment is made that the pink-colored, coarsely crystalline magnesium carbonate from the property of the North American Marble & Onyx Co. is almost identical in texture and composition with the black marble from the quarry of the United States Marble Co. These deposits were mentioned in a report of the United States Geological Survey published in 1909.[2] Here the statement was made

[1] Shedd, S., The building and ornamental stones of Washington: Washington Geol. Survey Ann. Rept. for 1902, vol. 2, pp. 87–103, 1903.
[2] Darton, N. H., Structural materials in parts of Oregon and Washington: U. S. Geol. Survey Bull. 387, p. 23, 1909.

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that "much so-called marble occurs along the foothills and ridges bordering Colville Valley from about Valley Brook northward, but it is dolomite or magnesite. The deposits about Valley and Chewelah are highly magnesian, and some of them are nearly pure carbonate of magnesia." At this time, however, magnesite from a source so remote from the principal centers of its consumption could not compete with the European magnesite, and little was thought of its commercial possibilities.

A number of samples from these deposits were analyzed by the Washington Geological Survey in connection with an investigation of the cement materials of the State. The results[1] showed that several samples had the composition of fair to high-grade magnesite. The only comments on these results, however, is that they show "a very high percentage of magnesite, and this makes them valueless as materials from which to manufacture Portland cement."

In January, 1916, specimens of brucite (a magnesium hydrate) from Stevens County were submitted to the United States Geological Survey by locally interested parties with inquiries as to their possible value. The field investigation of this brucite led to tests of the magnesite in which it occurred and to the acquisition of title and further prospecting of the old "marble" quarry. During the summer of 1916 other deposits in the same vicinity were subjected to considerable exploration, testing, and development. Mr. R. S. Talbot, of Spokane, began shipping on a commercial scale in November, 1916, and by the end of the year had shipped 715 tons of crude magnesite, valued at $7.50 a ton f. o. b. at point of shipment.[2]

The magnesite occurs in lenticular bodies in dolomite, the masses being of large dimensions, hundreds of feet in thickness and a thousand or more feet in length. It is evidently of sedimentary origin, although the recrystallization of the purer magnesium carbonate may have been secondary, possibly influenced by intrusion of basic magnesian rocks. The brucite is described as occurring in a shear zone in the magnesite. Of the following analyses Nos. 1 and 2 are quoted from the Washington Geological Survey and No. 3 was made in the laboratory of the United States Geological Survey.

Analyses of magnesite from Stevens County, Wash.

	1	2	3
Silica (SiO_2)	6.48	0.89	2.66
Iron and aluminum	4.20	.58	.86
Lime (CaO)	2.52	.....	.34
Magnesia (MgO)	41.53	45.76	45.80
Undetermined substances	.....	3.53	.....
Loss on ignition	43.60	49.24	50.04
	98.33	100.00	99.70

1. Light-gray magnesite, secs. 30 and 31, T. 32 N., R. 40 E. A. A. Hammer, analyst.
2. Pink coarsely crystalline magnesite, sec. 19, T. 31 N., R. 39 E., and secs. 24 and 25, T. 31 N., R. 38 E. R. W. Thatcher, analyst.
3. Analysis of a single sample submitted with correspondence; exact locality unknown. W. B. Hicks, analyst.

[1] Shedd, S., Cement materials and industry in the State of Washington: Washington Geol. Survey Bull. 4, pp. 126, 237, and appendix, 1913.
[2] Since the above statement was written R. W. Stone, of the United States Geological Survey, has visited the deposits in Stevens County, and his preliminary report has been published in Press Bulletin 340, released Oct. 25, 1917.

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This new material seemed to be acceptable as a source of magnesia in large quantity for refractory and other uses. The question arose as to its adaptability. Would it on actual test on a working scale prove as acceptable to furnace men as the iron-bearing varieties formerly received from Austria and Hungary? Its use in large quantities since early in 1917 suggests that it is a successful substitute for the imported material. As it occurs in eastern Washington, far from the principal markets for refractories, it will be at a considerable disadvantage in the matter of high overland freight rates, which may make competition with foreign supplies difficult. However, for use in western copper furnaces and steel plants the transportation factor will not be so greatly to the disadvantage of the Washington material.

The discovery of deposits of magnesite of a type hitherto unknown in the United States strongly suggests the possibility of finding similar deposits elsewhere in sedimentary rocks formerly assumed to be marble, limestone, or dolomite. For the present the suggestion is made that coarsely crystalline dolomite should be carefully examined. If, however, further study of the eastern Washington deposits shall develop a dependence on basic igneous intrusions as the explanation of the source of this particular enrichment of magnesium carbonate, it may show that the occurrence is of a decidedly exceptional type.

NEVADA.

So far as has been ascertained no further development has taken place on the extensive deposits of magnesite near St. Thomas, in Clark county. It is said that the large proportion of silica found in this material is considered objectionable. The ready disintegration of this material in water and the fact that the silica is largely in the form of grains of sand suggest the possibility of refining by some washing process, as is often done with kaolin.

Nothing has been heard from the deposit near Goldfield, mentioned in the report for 1915.

NEW MEXICO.

Magnesite was reported[1] to have been found near Albuquerque, but no response was obtained to inquiries made in an effort to verify this report. No confirmation of the newspaper report of the occurrence of magnesite near Las Cruces has ever been obtained.

CALCINING PLANTS.

Calcining plants for handling crude magnesite ore in California are mainly owned by the larger producing companies, which have them at or near their respective mines. Those in operation during 1916 were as follows: Western Magnesite Development Co., 32 miles from Livermore, Alameda County—2 vertical kilns; capacity 30 tons daily. Sonoma Magnesite Co., Cazadero, Sonoma County—1 rotary kiln; capacity 30 tons. Refractory Magnesite Co., Preston, Sonoma County—1 upright kiln; 5-ton capacity for dead-

[1] Min. and Eng. World, Apr. 29, 1916.

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burned. International Magnesite Co., National City, San Diego County—1 kiln; 20-ton capacity; calcining material from Santa Margarita Island, Lower California. Tulare Mining Co., Porterville, Tulare County—2 vertical kilns; 40 tons capacity. Porterville Magnesite Co., Porterville, Tulare County—1 rotary kiln; capacity 25 tons. American Magnesite Co., Porterville, Tulare County—2 rotary kilns; 50 tons capacity; has no mine but calcines for American Refractories Co. National Magnesite Co., Redwood City, San Mateo County—calcined material used for insulating purposes; has no mine. Sedan Calcined Magnesite Co., Berkeley, Alameda County—1 vertical kiln; 12 tons capacity. Pure Carbonic Co., Berkeley, Alameda County—2 vertical kilns; all material shipped to Hawley Pulp & Paper Co., of Oregon. Hoff Magnesite & Asbestos Co., Oakland—2 vertical kilns; capacity 10 tons; all output used for flooring, etc. Pacific Carbonic Gas Co., Oakland—2 vertical kilns; 14 tons capacity. Rex Plaster Co., Los Angeles—2 rotary kilns; plant destroyed by fire November, 1916. Tarpey mine, Piedra station, Fresno County—1 vertical kiln. Sears & Cubbage, Rutherford, Napa County—2 vertical kilns; 10 tons capacity; own no mine but do custom calcining. Adams, 22 miles from Rutherford, Napa County—5 kilns; 50 tons capacity; own no mine but do custom work, mainly for Sweasy mine. Since 1916 several of these plants have been enlarged in capacity and a number of new plants have been installed on these and other mining properties.

IMPORTS.

The following statistics of imports of magnesite are obtained from the Bureau of Foreign and Domestic Commerce, Department of Commerce:

Magnesite imported for consumption in the United States, 1914–1916.

	1914		1915		1916	
	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.
Magnesia:						
Calcined, medicinal	159,547	$19,342	94,309	$10,451	54,961	$14,659
Carbonate of, medicinal	46,183	2,527	48,817	2,757	8,202	1,048
Sulphate of (Epsom salts)	13,826,899	53,768	3,560,701	16,050	674,594	4,036
Magnesite:						
Calcined, not purified	243,633,205	1,323,194	53,148,730	232,071	18,539,704	204,183
Crude	26,708,381	54,677	99,527,772	255,140	150,689,445	634,447

The statement regularly contained in the reports of the Bureau of Foreign and Domestic Commerce of imports of merchanidse by articles and countries is what is termed "the statement of general imports" and embraces imported articles entered for immediate consumption on arrival and also articles entered for warehouse, as distinguished from the statement of "imports for consumption," which consists of imports entered for immediate consumption and withdrawals from warehouse for consumption.

The statement of general imports and the statement of imports entered for consumption for any period will differ to the extent that

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the value of entries for warehouse for the period differs from the value of withdrawals from warehouse for consumption. The term "entry for consumption" is the technical name of the import entry made at the customhouse and does not imply that the goods have been actually consumed but simply that they have been delivered into the custody of the importer and that the duties have been paid on the dutiable portion.

Magnesite calcined, not purified, imported into the United States, 1914–1916, in short tons.

By countries.

Country.	1914	1915	1916
Europe:			
Austria-Hungary	109,797	10,997	.....
Belgium	11	.....	.....
Denmark	103	.....	.....
Germany	912	307	.....
Greece	4,631	9,560	6,346
Italy	22	688	.....
Netherlands	4,717	2,706	235
Norway	.....	22	.....
United Kingdom:			
England	129	.....	2
Scotland	64	242	593
North America: Canada	197	2,543	2,094
South America: Venezuela	.....	508	.....
	120,583	27,573	9,270

By districts.

Customs district.	1914	1915	1916
Maryland	749	.....	.....
Massachusetts	2,506	56	.....
New York	10,935	5,835	1,040
Philadelphia	87,209	14,196	6,077
New Orleans	18,520	4,853	2
San Francisco	22	.....	.....
Southern California	445	95	57
Buffalo	5	180	32
Michigan	7	165	560
Ohio	.....	30	.....
St. Lawrence	175	2,112	1,450
Vermont	10	51	52
	120,583	27,573	9,270

NOTE.—The imports of crude magnesite are not classified in this way, being included under the heading "All other chemicals and drugs."

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SULPHUR, PYRITE, AND SULPHURIC ACID.

By PHILIP S. SMITH.[1]

SULPHUR.

DOMESTIC PRODUCTION.

Sulphur was produced in 1916 by seven mines—one in Louisiana and two each in Texas, Wyoming, and Nevada. The two largest producers of sulphur are the Union Sulphur Co., whose mine is at Sulphur, Calcasieu Parish, La., and the Freeport Sulphur Co., whose mine is near Freeport, Tex. These two companies furnished more than 99 per cent of the sulphur produced in the United States in 1916, and to avoid revealing their confidential reports the figures for the production of domestic sulphur will not be divulged. They will, however, be published later in the table of mineral production of the United States and in the tables for the States involved, but they will be lumped with other mineral products in such fashion that the quantity and value of the sulphur will not be disclosed.

The following extract from a letter published privately by the Freeport Sulphur Co. under the title "Freeport, Tex., harbor and its importance in the plan of national defense" may be of interest as an estimate of the domestic consumption of sulphur in 1916 furnished by persons intimately connected with the sulphur industry:

> The consumption of sulphur in this country for all purposes * * * was approximately 300,000 tons in normal times, of which probably less than 25 per cent was used in making powder. The entire consumption of sulphur itself in the United States during the year 1916 for normal uses plus the requirements for war munitions, totaled approximately 900,000 tons.

The accuracy of these figures is not vouched for by the Geological Survey; the quotation is given as a statement by those who should know approximately the volume of the domestic sulphur industry. Even if this estimate is not exact, it indicates the enormous expansion of the industry in 1916 over normal times, the necessity of keeping the main producing plants in constant operation, and the probable need for developing new sources of production.

So far the production of sulphur by the two main companies has shown no diminution. In fact, in 1916 each was able to mine and market more sulphur than ever before. The supply, however, at neither place is inexhaustible, and efforts should be made to reduce the unnecessary or unimportant consumption of sulphur. The companies are evidently conserving their resources either by refusing new and large orders or by raising the price of sulphur considerably to new customers. The stocks of sulphur at Sulphur, La., and at Freeport, Tex., are very large, though at one of the plants the sulphur in stock was slightly less at the end than at the beginning of 1916. Small stocks of sulphur have also been accumulated at several of the other mines, but their aggregate is of slight national importance.

[1] The statistics in this report were compiled by Miss Agnes L. Plaskett, of the United States Geological Survey.

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IMPORTS.[1]

Some sulphur is imported by the United States, but usually it is less than 10 per cent of the quantity consumed, and during 1916 the great expansion in consumption made the imports relatively still less significant. The table given below shows the usual classes and also the grades not specifically defined of sulphur imported during the last five years. More than 95 per cent of the sulphur received is crude, and although it is the least expensive of the various forms of sulphur imported, its value in 1916 was about 88 per cent of the combined value of all the sulphur imported in that year.

Sulphur imported and entered for consumption in the United States, 1912–1916.

Year.	Crude.		Flowers of sulphur.		Refined.		All other.[a]		Total.	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
1912	26,885	$494,778	1,311	$39,126	1,665	$40,933	66	$9,137	29,927	$583,974
1913	15,122	286,209	5,899	115,574	1,234	29,091	350	17,690	22,605	448,564
1914	23,610	398,984	621	17,214	1,800	47,568	104	14,171	26,135	477,937
1915	24,647	405,990	647	23,146	988	30,335	85	12,987	25,910	472,458
1916	21,289	358,416	425	18,408	455	15,020	66	12,940	22,235	404,784

[a] Includes sulphur lac and other grades not otherwise provided for, but not pyrite.

The countries from which the imported sulphur was obtained and the customs districts by which it entered the United States are shown in the accompanying table, which shows also that practically all the imported sulphur came from Japan and was entered at Pacific coast and Hawaiian ports.

Crude sulphur or brimstone imported into the United States, 1913–1916.

Countries whence exported and customs districts through which imported.	1913		1914		1915		1916	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
COUNTRY.								
Canada	98	$2,372	.....	.....	90	$2,000	30	$540
United Kingdom	101	2,905	123	$3,312	1	23	.....	.....
Italy	125	3,046	747	19,691	23	609	201	5,831
Japan	14,317	269,730	21,913	385,498	24,533	403,268	21,279	358,416
Other countries	.....	3	27	1,036	.....	.....	.....	.....
	14,641	278,056	22,810	409,537	24,647	405,990	21,510	364,787
CUSTOMS DISTRICT.								
Washington	.....	.....	.....	.....	.....	.....	3,277	55,401
Michigan	.....	.....	.....	.....	.....	.....	30	540
Boston and Charlestown, Mass	15	343	.....	.....	.....	.....	.....	.....
New York, N. Y	140	3,809	185	5,216	.....	.....	201	5,831
Los Angeles, Cal	1	42	1,320	26,493	750	12,171	.....	.....
San Francisco, Cal	5,110	86,146	12,460	218,842	11,862	186,743	10,129	168,161
Willamette and Portland, Oreg	6,802	128,709	7,164	124,907	7,287	119,534	6,505	110,884
Hawaii	523	8,923	1,182	22,669	960	17,529	1,368	23,976
All other	2,050	50,084	499	11,410	3,788	70,013	.....	.....
	14,641	278,056	22,810	409,537	24,647	405,990	21,510	364,787

[1] The statistics of imports have been furnished by the Bureau of Foreign and Domestic Commerce, Department of Commerce.

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EXPORTS.[1]

In 1913 the United States exported 89,221 long tons of sulphur, valued at $1,599,761; in 1914 the exports were 98,163 long tons, valued at $1,807,324; in 1915 they declined greatly and were only 37,312 long tons, valued at $724,679; in 1916, however, the exports increased to 128,755 long tons, valued at $2,505,857, or an increase of approximately 250 per cent in both quantity and value. From these figures it will be seen that in 1916 the exports exceeded the imports by 106,520 long tons and $2,101,073. The exports in 1916 were about 45 per cent greater than the exports in 1913, which may be taken as fairly representative of the normal conditions immediately before the war. The large quantity of sulphur exported was used chiefly for the manufacture of munitions and undoubtedly could be transported more advantageously in the form of sulphur than as explosives or sulphuric acid.

REPORTED LOCALITIES OF SULPHUR IN THE UNITED STATES.

The condition of the sulphur industry clearly shows the need of using to best advantage the product of the two remarkable deposits now affording nearly the whole of the production of the United States. If these deposits maintain their present output, the sulphur needed by the United States may be considered available, but, as a preparedness measure, the deposits now idle should be carefully considerod and search should also be made for new deposits in areas where geologic conditions are apparently favorable. In the following pages an attempt is made to list the known deposits of sulphur in the United States and to give a brief description of each, with references to some of the more important published reports concerning them. Aid in the compilation of the list has been given by Mr. William Y. Westervelt, mining engineer, of New York, who has generously loaned a bibliography compiled by him on this subject. The arrangement of the description of the deposits is by States.

ALASKA.

Sulphur deposits have long been known in Alaska. Although he overestimated their importance, Dall[2] as far back as 1869 reported concerning them as follows:

> Next to copper and coal, sulphur is probably the most valuable mineral of the Territory. It has long been in use as a means of obtaining fire by the coast tribes, and is reported, with great probability, to exist in large quantities in connection with the numerous volcanic peaks and craters of Alaska. It has been reported as existing in solution in most of the hot and mineral springs elsewhere referred to, and in a solid form in the following localities: Near the craters of the Aliaska volcanoes, on the island of Kadiak [Kodiak]; in the fissures of Shishaldin on Unimak, and in large quantities near Pogrumnoi [Pogromni] village on the same island; in a small crater on Akutan; in quantities on a small island southeast of Akhun [Akun]; near the summit of Makushin Volcano; in the mud craters of Atka; and finally on the volcanic peaks of Kanaga.

No recent information is available concerning any of these deposits except those on Makushin and Akun. Lawson,[3] who visited the Makushin deposits in 1906, states that they occur within the old

[1] The statistics of exports have been furnished by the Bureau of Foreign and Domestic Commerce, Department of Commerce.
[2] Dall, W. H., Alaska and its resources, p. 478, 1870.
[3] Lawson, N. O., Makushin sulphur deposits, Unalaska: Min. and Sci. Press, vol. 98, pp. 259–260, 1909.

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outer rim of the crater on the summit of the mountain. At this place there are innumerable holes, cracks, and vents from which steam and hot vapors issue, so that there is hardly a space 2 feet square free from them. The deposits are incrustations of crystallized sulphur from a few inches to 14 inches and, in exceptional places, even 24 inches thick. About 3 acres near the top of the ridge is free from snow, and in this area the sulphur deposits average from 9 to 12 inches thick. Adjacent to this richer area are from 9 to 12 acres containing sulphur deposits mixed with volcanic ash of decidedly lower tenor. The general opinion expressed by Lawson is that under normal conditions the Makushin deposits are not commercial deposits.

On Akun Island, one of the Aleutian Islands about 30 miles east of Makushin, sulphur claims were located close to Akun Head in the fall of 1916. The sulphur has been deposited around innumerable steam and gas vents. A specimen taken by the owner and said to represent an average of the deposits over an area 1,000 feet long by 600 feet wide is said to have shown 40 per cent sulphur. No shipments have been made from this property, but the owner expects to develop it actively during 1917.

CALIFORNIA.

Sulphur has been reported in a number of districts in California and has been mined on a small scale at three places. None of the properties, however, has been in operation in the last eight or ten years. In Kern County sulphur occurs cementing the gravels and detritus in beds 8 to 10 feet thick. At this place the sulphur is apparently derived through solfataric action and forms deposits that are distinctly superficial and of limited extent. Some production was reported from the Maricopa mine in this county prior to 1907.

According to Gale,[1] sulphur is found in small quantities in the deposits of Searles Lake, but this occurrence is regarded as of only mineralogic interest.

Sulphur is reported in the NW. ¼ sec. 28, T. 11 N., R. 23 W. San Bernardino meridian,[2] and on several other properties in the neighborhood.

In the northern part of California sulphur has been reported in Shasta, Colusa, and Lake counties. The location of the deposit in Shasta County is said to be south of Mount Lassen. This deposit was once mined, but even before 1909 it had been idle for some time.

In Colusa County some production of sulphur has been made from the Manzanita mine on Sulphur Creek. This mine is situated near hot sulphur springs, which emerge along the fault plane. Considerable sulphur was found in the upper part of the deposits in the mine, but apparently their volume was not great and the production of sulphur at that place has long since ceased. Several other properties on Sulphur Creek were at one time prospected for sulphur and a small refinery was erected. The deposits all appear to be superficial and the beds impregnated by sulphur are from 6 to 8 feet thick.

In Lake County considerable sulphur was mined at one time at Sulphur Bank, near Clear Lake. The deposit at this place seems to

[1] Gale, H. S., U. S. Geol. Survey Bull. 580, p. 297, 1915.
[2] Watts, W. L., California State Min. Bur. Rept., vol. 11, pp. 187-188, 233, 1892.

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have been formed through solfataric action, the sulphur being deposited near the surface in the open spaces of the adjacent rocks, which are of Cretaceous age. The deposit is of considerable scientific interest and has been described in detail by Becker,[1] but it long ago ceased to produce sulphur.

The occurrence of sulphur has also been reported in Los Angeles, San Diego, Santa Barbara, San Luis Obispo, Napa, and Sonoma counties. No specific location of the deposits is given, and they are not regarded as possible producers in the near future.

COLORADO.

Two deposits of sulphur have been mined in Colorado, but both have been idle for many years. These deposits are in Mineral County,[2] about 25 miles southwest of Creede. The nearest of these deposits to Creede is on Trout Creek, in volcanic rocks, associated with hot springs. The sulphur has been deposited on the surface in the open spaces, and the zone thus impregnated is in places 16 feet thick. A sample from the ore at this place contained 63 per cent sulphur. The other deposit is situated on Middle Fork, about 5 miles south of the Trout Creek deposit. Both deposits are similar in their general geologic conditions, but the Middle Creek deposit appears to be less extensively developed.

Vague reports of sulphur deposits in Gunnison County, in Teller County near Victor, and in Mesa County in the vicinity of Grand Junction have been received, but apparently no workable deposits of sulphur at any of these places have been found. The deposits in Gunnison County occurred on claims known as the Colorado, Goodhope, and Vulcan properties.[3] The ore is reported to contain 75 per cent sulphur. The deposit in the vicinity of Victor[4] was said to be of great purity.

FLORIDA.

Sulphur was reported in the vicinity of Tampa,[5] but probably either the report was incorrect or the deposit is too small to be of more than mineralogic interest.

IDAHO.

Sulphur springs are reported 5 miles east of Soda Springs, Bannock County, in the southeastern part of Idaho. They are situated along a fault between Carboniferous quartzite on the east and Cretaceous conglomerate on the west. The precipitation of the sulphur has cemented the gravels into a conglomerate so that a deposit containing about 10 per cent sulphur has been formed. A well-planned equipment was installed and the deposit was mined in the late nineties, but when it was visited in 1910 by members of the Geological Survey work had been long discontinued and the mill was dismantled. The conclusion of the Survey geologists[6] in 1911 was

[1] Becker, G. F., Geology of the quicksilver deposits of the Pacific slope: U. S. Geol. Survey Mon. 13, pp. 253–257, 1888.
[2] Larsen, E. S., and Hunter, J. F., Two sulphur deposits in Mineral County, Colo.: U. S. Geol. Survey Bull. 530, pp. 363–369, 1913.
[3] Mineral Industry during 1906, p. 697, 1907.
[4] Mineral Industry during 1907, p. 837, 1908.
[5] Day, D. T., Sulphur: U. S. Geol. Survey Mineral Resources, 1883–84, p. 864, 1885.
[6] Richards, R. W., and Bridges, J. H., Sulphur deposits near Soda Springs, Idaho: U. S. Geol. Survey Bull. 470, pp. 499–503, 1911.

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that the failure of an apparently well-backed attempt to develop these deposits will render improbable any further attempts in the immediate future. It is extremely doubtful if the deposits can be profitably worked by a process giving a complete recovery of the values, even to supply the local demand, in competition with the relatively high-grade deposits of Wyoming and Utah.

KANSAS.

Sulphur has been reported in Kansas,[1] but no location or description of the deposit has been given, and if sulphur occurs in that State it probably is of no commercial importance.

LOUISIANA.

Sulphur has been reported at a number of places in Louisiana, but the only one at which it has been developed is the Union Sulphur Co.'s property at Sulphur, Calcasieu Parish, in the southwestern part of the State. Most of the country in the vicinity is only a few feet above the sea and large areas are swampy. At the place where the sulphur mine is located, a low swell, a quarter of a mile in diameter, rises a few feet above the level of the surrounding plain. From the surface to a depth of several hundred feet this dome (as well as most of the surrounding country) consists of unconsolidated sands and muds full of water. Beneath the unconsolidated deposits is a limestone about 100 feet thick, locally known as the cap rock, because it covers the sulphur deposits. Next beneath the cap rock is 150 to 250 feet of limestone with some gypsum and large quantities of sulphur. Lower down the limestone decreases, and in the next few hundred feet the beds are mainly gypsum, with some sulphur and little limestone. Still lower down the rocks are massive gypsum. This gypsum member is about 600 feet thick and rests on beds of salt of unknown thickness.

The rocks below the unconsolidated deposits are apparently folded so that the rock surface forms much more of a dome than the gentle swell on the surface. In fact, though the surface swell rises only 13 feet above the general level of the surrounding country, the slopes of the sides of the rock dome are more than 45°. In other words, at a distance of 4,000 feet from the center of the dome a drill hole more than 4,100 feet deep failed to intercept the cap rock. The rock dome and the surface swell also do not correspond in position except in the eastern part of the field.

The sulphur does not occur in massive beds but is in stringers and lenses which traverse the adjacent rocks irregularly and in some places form as much as 70 per cent of their bulk. The origin of the sulphur has not been definitely proved, but the most generally acceptable explanation is that it has been derived through an alteration of the gypsum whereby the sulphur was set free from the lime with which it was originally combined.

Many of the early attempts to mine this deposit were unsuccessful because of the large amount of quicksand in the overburden. The double problem of reaching the deposit and extracting the sulphur was finally solved by Dr. Hermann Frasch. Briefly his process is as follows: Holes nearly a foot in diameter are bored to the deposit by drill

[1] Parker, E. W., Sulphur and pyrite: U. S. Geol. Survey Mineral Resources, 1895, p. 958, 1896.

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rigs similar to the rigs used in boring for oil, and the sulphur, which liquefies at about 116° C., is melted by the introduction of superheated water. After the sulphur has melted and collected at the bottom of the hole it is raised to the surface by the use of compressed air led by separate pipes down the drill hole. The sulphur in the liquid state is piped to large bins, where on cooling it consolidates. The solid sulphur in the bins is blasted down by powder, picked up by steam shovels, and loaded into box cars for railroad shipment or on open gondola cars for transportation to the company's loading dock at Sabine for ocean shipment.

The sulphur obtained is not further refined at the plant and is sold with the guaranty that it is at least 99.5 per cent pure. It contains no arsenic or selenium. Usually not all the sulphur in the adjacent rocks is melted out by one well, and consequently the practice has been to abandon a well after a certain length of time and later to go back to the same general place and sink another well. The distance to which the steaming affects the rocks varies greatly owing to local conditions. In some places wells less than 50 feet apart show no interrelation, whereas in other places wells more than 1,000 feet apart show distinct intercommunication. Already nearly 500 wells have been sunk in the deposit, but only four or five yield sulphur at a time. The number of wells in operation at a time is limited not only by the enormous equipment required to furnish the necessary hot water and air but also by the necessity of avoiding the setting up of excessive pressures underground.

The quantity of sulphur derived from individual wells differs considerably. The most productive well is said to have yielded over 100,000 tons of sulphur. The large quantity of sulphur that has been extracted has resulted in a notable settling of the surrounding region, and the local manager reports that in places the amount of settling is more than 200 feet. The result of this settling, if allowed to go on without any compensating reaction, would of course be to lower the surface below sea level. The settling is counteracted, however, by pumping sand and clay from the adjacent region with a dredge and piling this material up where subsidence has occurred. In this manner an artificial mound has been produced which roughly corresponds in position with the rock dome and the original surface swell.

No recent complete description of the mine has been published, but among the best of the earlier descriptions are those by Harris,[1] Kerr,[2] Willey,[3] and Pough.[4]

Mounds in some respects similar to the one at Sulphur have been reported at several places in southern Louisiana, and some of them have been successfully prospected for oil. Some sulphur has also been reported, but so far none of the deposits has produced any sulphur. Drill cores from borings in the mounds at Vinton and Edgerly,[5] west of Sulphur, show the presence of sulphur, and companies have been formed to prospect them for their sulphur content in addition to their oil, which has already been proved to be of commercial extent.

[1] Harris, G. D., U. S. Geol. Survey Bull. 429, pp. 99–103, 1910.
[2] Kerr, F. M., Assoc. Min. Eng. Jour., vol. 28, pp. 90–97, 1902.
[3] Willey, D. A., Eng. and Min. Jour., Dec. 14. 1907, p. 107, illustrated.
[4] Pough, F. H., Sulphur mines of the Union Sulphur Co.; Jour. Ind. and Eng. Chemistry, vol. 4, pp. 143–147, 1912.
[5] Fenneman, N. M., Oil fields of the Texas-Louisiana Gulf Coastal Plain: U. S. Geol. Survey Bull. 282, 1906.

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At Bell Island, in St. Marys Parish, a somewhat similar dome occurs, in which sulphur has been found in drill holes at various depths down to 2,600 feet. The best showings of sulphur have been found in the upper 200 to 300 feet, but no commercial development has been made.[1]

Numerous ill-considered enterprises have attempted to trade upon the success of the Union Sulphur Co. by offering shares in projects that are said to be in the vicinity of the producing mine. Doubtless some of these are merely ill-advised, but others are probably knowingly fraudulent. Investors in either class should therefore realize that the sulphur deposits in the mounds, so far as known, seem to be distinctly localized and do not appear to have great areal extent. Exploration of deposits of this type is difficult and extremely expensive and should not be undertaken except after thorough investigation of the precise area to be developed.

NEVADA.

Sulphur deposits have been reported at several places in Nevada, but the only ones that are now being mined are in the vicinity of Rabbit Hole Springs, in Humboldt County, in the northwestern part of the State, and near Cuprite, south of Goldfield, in Esmeralda County, in the center of the western part of the State.

The Rabbit Hole mines were discovered in 1874 and were producing in 1882 about six tons of sulphur a day.[2] The deposits occur in Tertiary rocks consisting of small fragments of volcanic rocks and beds of tuff that have been altered. The sulphur is obtained from open pits, tunnels, and underground chambers. The sulphur has been found in varying quantities for a distance of several miles, but its distribution is irregular. The deposit at this place is being developed by the Nevada Sulphur Co.

Little is known concerning the details of the geology and character of the deposits from which the sulphur at Cuprite is derived. The mine at this place, known as the Deep Gulch mine, appears to have been prospected for some time, but it has become a producer only since 1915, and its total production to date is small. Ransome[3] states that a considerable quantity of sulphur occurs near Cuprite, 12 miles south of Goldfield, in two main deposits. One is about a mile and a half northwest of the railroad station and the other is about half a mile northeast of the town. The first-named deposit is on the summit of a hill composed of horizontal beds of angular conglomerate overlain by a nearly horizontal stratum of white ashy material through which the sulphur is distributed in considerable masses. The sulphur deposit is in turn overlain by a layer of chalcedonic breccia, which is hard and resistant. The sulphur is obtained by tunneling under this capping. The rocks show evidence of strong solfataric action which has bleached and silicified them and deposited the sulphur. The deposit is about 600 feet long, but its thickness was not determined by Ransome.

The second deposit near Cuprite occurs in an altered rhyolite pumice containing alunite and appears to have been formed through solfatarie action. It is said to be smaller than the deposit first described.

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[1] Harris, G. D., op. cit., pp. 343-348.

[2] Adams, G. I., The Rabbit Hole sulphur mines, near Humboldt House, Nev.: U. S. Geol. Survey Bull. 225, pp. 497-500, 1904.

[3] Ransome, F. L., Geology and ore deposits of Goldfield, Nev.: U. S. Geol. Survey Prof. Paper 66 p. 109, 1909.

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Ransome also reports native sulphur about a mile due east of Tagonia Springs, near Goldfield, as irregular bunches in a greatly shattered and bleached rock which appears to have been originally a tuff-breccia. The sulphur is massive, and much of it occurs in lumps large enough to be easily sorted from the waste rock, but it is so unevenly distributed that its commercial importance is doubtful. The sulphur appears to have been deposited in connection with fumarole activity or by hot sulphurous waters. According to H. C. Morris, as reported by Ransome, a little sulphur has been found in the croppings on the Blue Bull claim, also near Goldfield.

A deposit of sulphur near Humboldt was mined to some extent 25 years ago, but no recent developments at this place have been reported. The deposit occurs in the vents of extinct hot springs, which rise 20 to 50 feet above the adjacent plains. The quantity of sulphur appears small, and Russell,[1] who examined the deposits, states that their economic importance does not warrant further expenditure.

Sulphur was reported by Spurr [2] as occurring about 10 miles north of Silver Peak, in Esmeralda County. It is adjacent to a dikelike mass of rhyolite that cuts gently folded white and red rhyolitic tuffs of Tertiary age. The sulphur occurs throughout, cementing the cracks and crevices, but generally the seams are not over a fraction of an inch thick.

Sulphur is said to occur in the deposits on the flanks of the Sweetwater Mountains and of the White Mountains, both of which lie near the California-Nevada boundary. No details, however, concerning these deposits have been received.

In the vicinity of Steamboat Springs, between Carson and Reno, sulphur has been found in small quantity. Becker,[3] who examined this region, states that the sulphur has been deposited through the oxidation of sulphureted hydrogen through contact with air or sulphurous anhydride. Although the sulphur is rather widely disseminated, he reports that probably not more than a pound or two could be collected in any one specimen.

Sulphur is noted by Wilson [4] as occurring in the vicinity of Columbus, in Esmeralda County, but no details are given.

NEW MEXICO.

No deposits of sulphur have been recently mined in New Mexico. In 1885, however, Day [5] reported, among other new discoveries of sulphur in that year, a deposit in New Mexico concerning which he said

> Mr. Jewett further reports sulphur deposits north of Lone Mountain or Red Peak, 5 miles distant from the town of White Oaks, N. Mex. In these deposits the percentage of sulphur is about 50 per cent; gypsum occurs with it. The extent of these deposits it unknown.

No later information concerning the sulphur deposits in this region is available.

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[1] Russell, I. C., Sulphur deposits in Utah and Nevada; New York Acad. Sci. Trans., vol. 1, pp. 172–175, 1882.
[2] Spurr, J. E., Alum deposit near Silver Peak, Esmeralda County, Nev.: U. S. Geol. Survey Bull. 225, pp. 501–502, 1904.
[3] Becker, G. F., Geology of the quicksilver deposits of the Pacific slope: U. S. Geol. Survey Mon. 13, 1888.
[4] Wilson, A. W. G., Pyrites in Canada: Canada Dept. Mines, Mines Branch, Pub. 167, p. 7, 1912.
[5] Day, W. C., Sulphur: U. S. Geol. Survey Mineral Resources, 1885, p. 496, 1886.

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NEW YORK.

Sulphur deposits have been reported in New York at Springport and near Cayuga in Cayuga County,[1] at Byron in Genessee County, and at Manlius and Syracuse in Onondaga County. In the two last named localities, the sulphur is deposited by sulphur springs and is in very small quantity. The reported deposits in Cayuga County are also of only mineralogic significance.

TEXAS.

The sulphur deposits of Texas lie in two main areas, one near the Gulf in the Coastal Plain province and the other in the western part of the State. In the area near the coast the only producing mine is that of the Freeport Sulphur Co., already stated to be one of the two largest producers of sulphur in the United States.

The geologic conditions at the mine of this company closely resemble those at the Union Sulphur Co.'s mine in Louisiana in that a surface swell is approximately above a deep-seated rock dome. The rocks at the two places are identical in appearance and the distribution and relation of the sulphur are the same. The surface swell rises about 25 feet above the level of the surrounding plain. The plain is practically at sea level, and at times of exceptionally high water it is submerged except where it is protected by artificial dikes. The sea is less than 2 miles distant from the mine, and to the east is Brazos River, one of the largest rivers of Texas.

The sulphur is mined by the so-called Frasch process, which in general is the same as the process used at the mine of the Union Sulphur Co. Various modifications have been made to meet local conditions, but the essential features of the plant are several wells in operation or in process of being drilled and great batteries of boilers capable of furnishing millions of gallons of superheated water.

The Freeport Sulphur Co. began active operations in the later part of 1912. Since that time it has not only acquired and developed the mines but has established transportation and dock facilities and solved many of the intricate problems which arise in a large enterprise of this sort. The company has built a loading dock at the mouth of Brazos River, and vessels drawing 18 feet of water can tie up to it at any stage of tide. Boats enter with cargoes of Mexican oil, which is used at the mine, or load with sulphur for ocean shipment. A railroad line has been built from Freeport, so that considerable sulphur is shipped by rail. During 1916 the Freeport Sulphur Co. sold more sulphur than ever before and at the same time somewhat increased its stock of sulphur. The extraction of the sulphur has not yet caused noticeable subsidence of the surface, though at one place a crack several hundred yards long was seen along which a displacement of 6 to 8 inches had occurred.

Indications of sulphur have been reported at many other localities in the Coastal Plain province of Texas, namely, at Spindletop, Sour Lake, Batson, Matagorda, Kiser Hill, High Island, and Damon Mound. These are all mounds somewhat similar to the one already noted at Freeport. Each of these has been more or less completely

[1] Day, D. T., Sulphur: U. S. Geol. Survey Mineral Resources, 1883-84, p. 864, 1885.

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described by Fenneman,[1] from whose report the following statements are largely taken.

In the Spindletop region deposits of sulphur occur both above and below the horizon of the oil, though of necessity it is less known in the latter position. Well No. 1 of the National Oil & Pipe Line Co. reported 40 feet of pure sulphur immediately above the cap rock, and 40 feet of solid sulphur is reported in the rocks of wells No. 2 and No. 3 of the same company, though the wells are separated by some hundreds of feet. In the Higgins No. 5 well 8 feet of supposedly pure sulphur occurs at a depth of 1,020 to 1,028 feet, at a horizon 1,617 feet above the main oil-bearing rock. There is also 10 feet of sulphur mud 5 feet above the bed of sulphur. In the Higgins No. 1 well 10 feet of sulphur is reported at the bottom of the well at a depth of 1,030 to 1,040 feet, underlying the main oil sand. In well No. 4 of the Southern Oil Co., 1 foot of sulphur was reported just above the cap rock at a depth of 982 feet below the surface. In the same well 3 feet of sulphur was reported at a depth of 845 feet. On the west side of the Yellow Pine tract, block 33 of Gladys City, 15 feet of sulphur at a depth of 970 feet was said to underlie the main oil horizon. In the Heywood No. 2 well 33 feet of sulphur is reported immediately above the oil rock at a depth of 950 feet. In the Heywood No. 3 well sulphur occurs at four horizons with thicknesses of 10, 15, 8, and 20 feet, respectively. In the Gladys No. 3 well 70 feet of sulphur is reported above the oil. In most of the wells mentioned sulphur was supposed to be practically unmixed with earthy material. In the Higgins No. 7 well 24 feet of sulphur mixed with white rock occurred immediately above the oil horizon, which was reported at 746 feet. In the Higgins No. 10 well, at a depth of 930 feet, 8 feet of soft sulphur and white and gray rock occurred 34 feet above the top of the oil-bearing rock. It is rather significant that three of the small number of wells drilled beyond the oil horizon encountered sulphur below the oil. There is small evidence to support the popular impression that sulphur occurs in definite beds or continuous masses of large size.

The Sour Lake field is in Hardin County, about 20 miles west by north of Beaumont. Sulphur is said to have been found in the soil, but it is not known that this was considered significant before the actual discovery of the oil. Like the sour waters of the springs and lake, sulphur has subsequently received some attention as an associate of oil in the Coastal Plain on account of its very frequent occurrence in the oil fields.

In the Batson field sulphur has been reported from only one well, namely, on the Kiser & Middlebrook tract, where it is said to have been found in a rock locally called "cap rock." It is perhaps significant to note that in the Batson field gypsum occurs in but very small quantities.

Sulphur is reported from various wells in the Matagorda field, but always at or near the horizon of the oil. It exists either in disseminated form in the sand or clay or as a pure crystalline mass filling the crevices of the limestone. In the latter form, it has been reported at the Lane No. 1 well, where 60 feet of solid sulphur with a possible addition of 30 feet more occurs at a depth of about 1,035

[1] Fenneman, N. M., Oil fields of the Texas-Louisiana Gulf Coastal Plain: U. S. Geol. Survey Bull. 282, 146 p., 1906.

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feet. In the same well small grains of sulphur were reported in a light-colored sticky mass below the limestone. The Dean, Johnson, and Griffith No. 2 wells each report a little sulphur at about the horizon of the oil.

Sulphur is reported from various depths in drillings made at Kiser Hill and always in connection with rock and frequently in the form of small crystals. Pyrite is likewise abundant. A sample from the bottom of well No. 4 at a depth of 760 to 812 feet contains soft streaks which consist of friable sandstone containing small veins of salt. Similar cores are said to have contained crystalline sulphur.

On High Island, near the southwest corner of Jefferson County, are numerous springs which are charged with hydrogen sulphide. The mouth of one well near these springs was stuffed with straw and a year later the straw was so thickly coated with sulphur that it resembled a solid mass of sulphur.

In the Guffey No. 1 well, at a depth of 729 feet, a 17-foot bed of loose dirt and sulphur was struck. This was evidently a deposit formed by the action of hydrogen sulphide or sulphide water deposited in uncompacted sediments. The sulphur, like the porous bed which contains it, probably had a very small lateral extent.

At Damon Mound, in the northwest corner of Brazoria County, sulphur is reported to have occurred in the Herndon well at a depth of 549 to 579 feet. The sulphur at this place was intimately associated with gypsum.

The sulphur deposits in the western part of the State occur mainly in what was formerly part of El Paso County, but has been subdivided into Reeves and Culberson counties. These deposits have long been known, but recently, owing to the high prices paid for sulphur, they have been the scene of renewed activity, and one mine, that of the Michigan Sulphur & Oil Co., has reported a small production of sulphur.

In 1904 Richardson[1] visited the region and reported sulphur at the following places: At Maverick Springs, 5 miles northwest of Maverick Springs, 6 miles north of Rustler Springs, 10 miles northeast of Rustler Springs, 1½ miles northwest of the last locality, 4 miles southeast of Delaware Springs, 10 miles north of Rustler Springs, near Stinking Seep, on Cottonwood Draw, and 6 miles northwest of Toyah. The sulphur at all these places occurs at or near the surface and is associated with beds of gypsum and limestone. It is found throughout a wide area and locally it is fairly well concentrated. Richardson states that economic mining on a small scale would probably be profitable but that the value of the field as a whole can not be determined without considerable further prospecting.

Little, however, was done in prospecting these deposits for several years. In 1916 renewed interest resulted in considerable work on these deposits, and they were visited by W. B. Phillips,[2] from whose description the following statements are taken:

> Sulphur has been found in greater or less quantities at the following places in Culberson County:
>
> Secs. 17 and 18, block 45, Maverick Springs. The Kyle property is in sec. 18.
>
> Sec. 2, block 111. The Dot property is here.

[1] Richardson, G. B., Native sulphur in El Paso County, Tex.: U. S. Geol. Survey Bull. No. 260, pp. 589–592, 1905.

[2] Phillips, W. B., The sulphur situation in Culberson County, Tex.: Manufacturers' Record, Dec. 7, 1916.

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Secs. 15 and 16, block 111. The Michigan Oil & Sulphur Co. is here, as also the Virginia (Felch).
Sec. 14, block 113, W. H. Hicks.
Secs. 7, 8, and 10, block 42, Pat, Lone Wolf, and Golson.
Secs. 10 and 15, block 114, Cooksey.
Secs. 10, 11, 18, 19, 22, and 23, block 115.
Sec. 1, block 46, University land.
Sec. 43, block 62, Texas & Pacific Railway land.
Secs. 4, 5, 9, 10, and 24, block 109. Nelson claims are in secs. 8 and 9.
Secs. 8, 16, 17, and 18, block 61. The Grand claims are in secs. 17 and 18.
Sulphur has also been found at the following places in Reeves County: Sec. 17 or 9, block 59, near the old Hulen, White & Ross shallow oil wells, and within a short distance of the deep well (4,100 feet) bored by The Texas Co. for oil.

Concerning the economic importance of these deposits, Phillips says:

> There is a good deal of sulphur in Culberson County and some of it can be cheaply mined. It has so much in its favor. What the cost of extraction will be and what the cost of transportation remains to be seen. * * * The prospecting and opening of these sulphur deposits requires considerable capital. This country is no place for a man without means.

Sulphur was reported in Smith County, cementing gravels near the old Brooks saline, in the southwestern part of the county. It was estimated that the sulphur formed about 10 per cent of the mass.

The following occurence of sulphur in Texas other than those mentioned above are given by Simons.[1] Doubtless at many of these places the sulphur does not occur in commercial quantities. Burleson County, Sulphur Bluff, 9 miles below Mosley Ferry; Edwards County; Fayette County, Chalk Bluff, 12 miles below La Grange; Nueces County; Starr County; Tom Green County; Webb County, 1 mile below Laredo.

UTAH.

In central Utah, about 20 miles north of Beaver, is a small mining camp called Sulphurdale, where sulphur deposits have been mined in the past by the Utah Sulphur Co. These deposits are locally known as the Cove Creek sulphur beds. According to Lee[2] the sulphur extends from the surface to a considerable but unknown depth in beds of soft rhyolitic tuff. These deposits have been known since 1869 and have been more or less continuously mined on a small scale. Probably the sulphur beds are located in or near a zone of strong faulting and volcanic activity. The sulphur in places occurs in cylindrical cores, 10 to 15 feet in diameter, having a radial structure. In other places it forms irregular veins, some of which are several inches thick. Lee states that the origin of the sulphur is to be attributed to the gases associated with volcanic eruption, which escape along the fault planes. The process of formation and concentration is apparently still going on. A furnace was at one time in operation at this plant and the sulphur was extracted from the ore in retorts subjected to steam under pressure.

Near Sulphurdale, trending in general in a northeasterly direction, are other sulphur deposits, one of which, about 3 miles northeast of the camp, has been developed to some extent. The character and origin of this deposit seem to be the same as those of the deposits at Sulphurdale, but its known extent is smaller.

[1] Simons, F. W., The minerals and mineral localities of Texas: Tex. Univ. Mineral Survey Bull. 5, p. 77, 1902.
[2] Lee, W. T., The Cove Creek sulphur beds, Utah: U. S. Geol. Survey Bull. 315, pp. 485-489, 1907.

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Sulphur deposits in the San Rafael Canyon, 10 to 20 miles west of the town of Green River, have been described by Hess.[1] Apparently they were formed by springs which deposited the sulphur near the surface. The deposits are said to occupy an area 100 by 170 feet.

Hess also reports sulphur deposits associated with springs about 5 miles upstream from those in San Rafael Canyon and still others 15 miles farther north and associated with springs on Cedar Mountain. Apparently there are many deposits in this general region, for the occurrence of sulphur is reported 7 miles south of Cedar station on Price River and at a place about 20 miles north of Price. At the latter locality the country rock is lava, and a specimen said to be representative of the deposit as a whole yielded 25 per cent sulphur

VIRGINIA.

According to Parker,[2] sulphur is reported in small quantities on Potomac River about 25 miles above Washington, presumably in Loudoun County. The precise location of this deposit is not recorded, but the geology of the general region is such as to indicate that the deposit is not of commercial value.

WASHINGTON.

Sulphur has been reported to occur in the Cascade Mountains in Washington.[3] In his notes on this occurrence Westervelt[4] states that the deposit is presumably near Sulphur Springs in Lewis County, but that it possibly is elsewhere, as, for instance, at Sulphur Creek, Snohomish County.

WYOMING.

There are four districts in Wyoming concerning whose sulphur deposits definite information has been obtained, namely, Cody, Thermopolis, Sunlight Basin, and Sweetwater Creek. Of these districts, Cody alone produced sulphur during 1916, two companies in the district, the Midwest Sulphur Co. and the Cody Sulphur Co., having reported a production in that year.

The sulphur deposits near Cody were described by Woodruff[5] in 1907, and although the general description is true, subsequent developments have modified many of its minor details. According to Woodruff, the deposits lie about 3 miles west of Cody, near the base of Cedar Mountain. The area in which they occur is about 2 miles long and a quarter of a mile wide and is south of Shoshone River. The sulphur occurs in irregular masses in cavities and veins in the country rock, which consists of limestone and travertine. In the richer pockets the sulphur forms 30 to 50 per cent of the mass. The thickness of the workable ground is in general not more than 20 feet, so that open-cut methods of mining are used. The field evidence clearly shows that the deposits have been formed through the action of hot springs that have brought sulphur-impregnated waters to the surface. The sulphur is extracted from the ore by subjecting it to

[1] Hess, F. L., A sulphur deposit in the San Rafael Canyon, Utah: U. S. Geol. Survey Bull. 530, pp. 347–349, 1913.
[2] Parker, E. W., Sulphur and pyrite: U. S. Geol. Survey Mineral Resources, 1895, p. 958, 1895.
[3] Mineral Industry, vol. 5, p. 514, 1896.
[4] Westervelt, W. Y., unpublished bibliography.
[5] Woodruff, E. G., Sulphur deposits at Cody, Wyo.: U. S. Geol. Survey Bull. 340, pp. 451–456, 1908.

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steam under pressure in retorts into which the loaded cars in which it has been placed are run. Probably not more than two-thirds of the sulphur in the ore is recovered by this method of treatment.

The deposits near Thermopolis have produced more sulphur in the past than those near Cody, but they were idle during 1916. According to Woodruff,[1] who examined them, the deposits are about 3½ miles northwest of Thermopolis, near Owl Creek. The beds containing sulphur extend for about a mile in a northwesterly direction. The geologic relations are practically the same as at the Cody deposits—the sulphur is associated with beds of limestone and travertine and has been formed by the action of hot springs. The methods of mining and extraction are nearly identical with those followed at Cody.

About 32 miles northwest of Cody and 14 miles from the Yellowstone National Park are the sulphur deposits of the so-called Sunlight Basin. According to Hewett,[2] the deposits occur in seven isolated groups, six of which lie in a belt about 3½ miles long which crosses the valley of Sunlight Creek. The sulphur cements the surface débris and incrusts irregular open fractures in the country rock, which is a bleached rhyolite. It is believed that these deposits have been formed through the decomposition of sulphureted hydrogen, which issues even now from the cracks and crevices, although no volcanic vents are known in the neighborhood. No hot-spring deposits, such as travertine, were recognized in the vicinity of the sulphur deposits. On the whole the sulphur is distinctly superficial, and Hewett states in his report that he does not believe that the deposits will become important.

Twelve miles south of the Sunlight Basin deposits are those on Sweetwater Creek, near the summer settlement of Wapiti. These deposits are confined, according to Hewett, to a narrow strip adjoining Sweetwater Creek on the east, and the area in which sulphur has been found does not exceed 20 acres. Most of the sulphur occurs as a cement of the detritus of alluvial fans. No siliceous sinter or travertine occurs near the deposits. The sulphur appears to have been derived through the decomposition of sulphureted hydrogen contained in gases that issue from crevices in the igneous rocks of the region. The deposits are small, and under normal prices for sulphur there is little chance that they can be successfully exploited except for purely local needs.

In addition to these deposits that have been examined by members of the Geological Survey, sulphur beds have been reported in Uinta County in the extreme southwest corner of the State, south of Evanston, on Sulphur Creek, and on the flanks of the Wind River Mountains in the central part of the State. No details concerning either of these deposits have been obtained.

MINERALOGIC OCCURRENCES.

In addition to the foregoing localities there are a number of other places where sulphur has been reported as a mineral. None of them are of the slightest commercial importance, but mention of them is made for the sake of listing the reported occurrences. In practically all these places the sulphur has resulted from the decomposition of

[1] Woodruff, E. G., Sulphur deposits near Thermopolis, Wyo.: U. S. Geol. Survey Bull. 380, pp. 373-380, 1909.

[2] Hewett, D. F., Sulphur deposits of Sunlight Basin, Wyo.: U. S. Geol. Survey Bull. 530, pp. 350-362, 1913.

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some metallic sulphide, such as galena or pyrite. In Kansas sulphur is reported near Galena on the weathered surface of sphalerite (zinc sulphide). In Maryland sulphur has been reported on galena at the Mountain View mine, in Carroll County. In Massachusetts [1] sulphur has been reported in mica slate at Conway, Shelburne, and Warwick; in a green micaeous rock in Medfield and Chester; in a hornblende gneiss on Trowbridge Hill, at Northfield; in a lead mine at Hatfield, and in hornblende schist near Leverett. In Montana sulphur has been reported incrusting the ore at the Bunker Hill mine, near Henderson. In Ohio sulphur has been reported at Put in Bay. In Pennsylvania sulphur has been reported on the galena ore at the Wheatley mine, near Phoenixville. In Wisconsin sulphur has been reported in the lead region, having probably been derived from pyrite and marcasite.

USES.

Sulphur is used for many different purposes, but the greatest consumption is in the manufacture of paper and in the preparation of chemicals. According to information from paper manufacturers about one-eighth of a ton of sulphur is used for each ton of sulphite pulp manufactured. Although some of the sulphur required for this purpose is derived from the burning of ores of sulphur, most of the pulp manufactured in this country is made with native sulphur. According to census returns, the production of sulphite pulp in the United States in 1914 consumed 136,456 short tons of sulphur.[2] By comparing the statistics for 1914 with those of 1904 it appears that the average annual increase in the consumption of sulphur in the paper industry is very small.

Under normal conditions, not very much native sulphur is used for the manufacture of sulphuric acid except that of the best quality, but lately, with the heavy demand for large quantities of all grades of acid, the quantity of sulphur so used has increased notably. According to the reports of the producers of acid, 261,574 long tons of domestic sulphur and 10,903 long tons of foreign sulphur were used by them in 1916. A considerable increase even over this enormous consumption must, however, be expected if importations of pyrite are materially decreased. Statistics of the consumption of sulphur in chemical industries other than the manufacture of acid are not available.

Some native sulphur is used in various agricultural activities in addition to the direct use of sulphur for sulphuric acid in the manufacture of fertilizers. The quantity used for these purposes, including spraying, dipping, and dusting (sulphuring), is roughly estimated as between 35,000 and 40,000 tons a year. Possibly the use for agricultural purposes will be much greater in the future, for experiments suggest that native sulphur applied to some soils acts as a direct fertilizer.[3]

No statistics regarding the quantity of native sulphur used for explosives during 1916 are available. A large quantity of low-power powder is made even in times of peace. Gen. Weaver[4] states

[1] Emerson, B. K., A mineralogical lexicon of Franklin, Hampshire, and Hampden counties, Mass.: U.S. Geol. Survey Bull. 126, p. 164, 1895.
[2] Ruff, W. A., Paper and wood pulp industry: Census of manufactures, 1914, 19 pp., 1917.
[3] O'Gara, P. J., American Smelting & Refining Co.'s test with sulphur and sulphuric acid on soils: Min. and Sci. Press, vol. 114, pp. 840–843, 1917.
[4] Weaver, E. M., Military explosives, pp. 98–104, John Wiley & Sons, 1915.

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that the black powder used by all countries is approximately uniform in composition and contains about 10 per cent by weight of sulphur. Brown powder contains about 3 per cent of sulphur. Brown powder now is practically obsolete, but black powder is still used in the army chiefly for saluting, as an igniter for nitrocellulose powders, and in fuses and primers. Sulphur is also mixed, according to Weaver, with potassium chlorate and antimony sulphide in the ratio 22:472:30, to form the percussion mixture for small-arms cartridges used by the United States Army.

PYRITE.

CONDITION OF THE INDUSTRY.

The demand in 1916 for pyrite to meet the unusual consumption of sulphuric acid created by the war increased notably over the demand in 1915. Never before was so much pyrite produced or imported by the United States, and prices increased throughout the year. Even with the stimulus of an increased demand and good prices, however, the number of pyrite mines in operation in the United States showed practically no increase. Six new producers were operating in 1916, but their plants were all small, several of them recovering the pyrite from coal, and their total yield was only about 2,000 tons. On the other hand three mines that were in operation in 1915 and that during that year yielded over 7,000 tons of pyrite were idle in 1916, and at one of the former larger producers almost the entire year was spent in repairing the damage from the caving of the mine shaft, so that it produced much less than its normal output of pyrite.

The increase in production is therefore to be attributed to the greater yield from the old mines rather than to the opening of new deposits. This condition is believed to be due to the lack of initiative in attempting to find suitable deposits rather than to the absence of undeveloped deposits of commercial value. The low cost of foreign pyrite, under normal conditions, has deterred the pyrite users from seeking a domestic supply and from encouraging the expenditure of the money necessary to prospect and develop properties that appear to promise success. Under the shortage of foreign pyrite that seems inevitable, search for domestic supplies must be prosecuted with vigor. The deposits to be of greatest value in the present national crisis must be east of Mississippi River and within easy transportation distance of the great fertilizer and chemical industries in the Appalachian Mountains and the eastern United States. In the Appalachian Mountains are many abandoned mines, originally developed for the gold or copper content of their ore, which may possibly produce pyrite. The Geological Survey, in cooperation with the several State surveys, is at present engaged in preparing an inventory of mines of this sort. Owners of properties that may belong to this class are earnestly requested to furnish information regarding the geologic and geographic occurrence of their deposits in order that the list may be complete and available for those requiring information concerning pyrite lodes that are possibly susceptible of development.

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USES.

As is generally known, iron disulphide (FeS_2), pyrite or marcasite, when pure, contains about 53 per cent of sulphur and 47 per cent of iron. It is used mainly for the manufacture of sulphuric acid, and more than 1,250,000 long tons is consumed each year for this purpose. Pyrite, as commercially used, is generally referred to one of two classes, lump or fines. The lump ore, as its name implies, consists of pieces more than half an inch in diameter, with a certain allowable proportion of smaller particles, and is used in the condition in which it comes from the mine with little more than a sorting according to size. The fines are in smaller particles and generally have been obtained by crushing the ore so small that the pyrite can be separated from worthless gangue by some mechanical process, or the ore has disintegrated through having been leached. Owing to the different methods of treating these two kinds of pyrite for the extraction of their sulphur, they can not be used interchangeably. The lump ore commands somewhat higher prices than the fines, but of course it is more difficult to obtain a lump ore with as high a sulphur content as that of fines. As a result, only a few mines or parts of a mine can furnish lump ore and maintain a high enough sulphur content, whereas suitable fines may be obtained even from deposits in which the pyrite is sparsely disseminated.

No definite lower limit can be placed on the proportion of sulphur that a pyritic ore must contain in order to be used. In practice, however, ore containing more than 40 per cent is specified, and practically none of the acid companies use ore that carries less than 35 per cent of sulphur.

Several elements or substances by no means rare in pyritic ores are objectionable for material to be used in the manufacture of sulphuric acid and decrease the value of the ore in which they occur or can be used only by means of special treatment. According to Felding,[1]

When ores contain, among others of minor importance, the following minerals, these will at the ordinary temperatures of burners used by sulphuric acid manufacturers retain in chemical combination the following proportions of sulphur, which will therefore not be available for making acid:

For each per cent of	There will be found
Zn	0.50% S
ZnO	.80
Cu	.50
CuO	.40
Pb	.15
PbO	.14
CaO	.57
MgO	.80
Fe_2O_3	.60

This is on the assumption that all the sulphides are converted to sulphates, which is by no means the case.

Furthermore, arsenic and antimony have a bad effect on the resulting acid, but some of the large fertilizer plants do not reject an ore containing less than 1 per cent of arsenic. These substances, however, are very undesirable if the pyrite is used in plants manufacturing acid by the contact process, as they attack the platinum and cause it to lose its efficiency. According to Wilson [2] pyrite carrying

[1] Felding, F. J., The manufacture of sulphuric acid: Mineral Industry, vol. 7, p. 653, 1898.
[2] Wilson, A. W. G., Pyrites in Canada: Canada Dept. Mines, Mines Branch, Pub. 167, p. 22, 1912.

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more than 8 per cent of copper can not be profitably employed in the manufacture of sulphuric acid. Carbonaceous material is apparently undesirable mainly because it yields a dark-colored acid, but this should have no effect upon its use for the low-grade acids required in the manufacture of fertilizers and similar materials.

PRODUCTION.

The domestic production of pyrite in 1916, as shown in the accompanying table, was 423,556 long tons, valued at $1,965,702, an increase of about 30,000 long tons in quantity and of about $290,000 in value, as compared with the production in 1915. The consumption of pyrite ore in 1916—that is, the domestic production plus imports—amounted to about 1,670,000 long tons and was about 310,000 long tons greater than the consumption in 1915. This increase was largely attributable to the greater demand for sulphur in industries connected with the war and was made possible mainly because of increased imports.

In addition to the pyrite ores reported here, returns from manufacturers of sulphuric acid (see p. 431) show that 568,116 long tons of domestic copper-bearing sulphide ores, 196,404 long tons of foreign copper-bearing sulphide ores, 531,625 long tons of domestic zinc-bearing sulphide ores, and 92,002 long tons of foreign zinc-bearing sulphide ores were treated in 1916 for their sulphur as well as for their metallic content.

Pyrite produced in United States in 1916.

State.	Quantity (long tons).	Value.	Average price per ton.
California	145,762	$565,699	$3.88
Illinois	20,482	51,432	2.51
Indiana	772	2,445	3.17
Ohio	13,551	36,114	2.67
Virginia	148,502	925,243	6.23
Other States [a]	94,487	384,769	4.07
	423,556	1,965,702	4.64

[a] Includes Georgia, Missouri, New York, Pennsylvania, South Carolina, South Dakota, Tennessee, and Wisconsin.

This production was reported from 57 mines in 13 States. Grouped by certain broad general regions, 218,052 long tons, valued at $1,245,306, an average of $5.71 a ton, came from the Appalachian region, including New York, Virginia, South Carolina, and Georgia; 36,242 long tons, valued at $93,749, an average of $2.59 a ton, came from the region east of the Mississippi, including western Pennsylvania, Ohio, Indiana, Illinois, and Tennessee; 23,500 long tons, valued at $60,948, an average of $2.59 a ton, came from the region west of the Mississippi, including Missouri, Wisconsin, and South Dakota; and 145,762 long tons, valued at $565,699, an average of $3.88 a ton, came from California, the only State west of the eastern front of the Rocky Mountains that reported production of pyrite for its sulphur content.

The crude ore sold amounted to about four times the quantity of concentrate sold, the record showing that 336,386 long tons of lump

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ore, valued at $1,588,691, and 87,170 long tons of concentrate, valued at $377,011, were marketed. According to these figures the average price of the crude ore was $4.72 a long ton, the average price of the concentrate was $4.33 a long ton, and the average price of the total pyrite sold was $4.64 a long ton. In the foregoing statement the term "crude ore" means essentially lump ore and the term "concentrate" means essentially fines.

PRODUCTION BY STATES.

ALABAMA.

No pyrite was mined in Alabama in 1916. Three mines formerly in operation were idle throughout the year, and no new mines were reported. The area in which possible pyrite deposits of commercial value might occur is limited to the extreme northeastern part of the State.

ARKANSAS.

No pyrite was mined in Arkansas in 1916. One mine under development in 1915 was not yet in a producing condition. The possible productive area is in the western part of the State.

CALIFORNIA.

California ranked second among the States in both quantity and value of pyrite sold in 1916. The marketed production was 145,762 tons, valued at $565,699, an average of $3.88 a ton. This was an increase of more than 13,000 tons in quantity and of nearly $70,000 in value over the production in 1915. All the ore produced was sold in the crude state and no concentrates were reported. The pyrite was produced by the Mountain Copper Co., of Shasta County; the Vantrent Mining Co., in Placer County; and the Leona Chemical Co. and Stauffer Chemical Co., in Alameda County. All these properties have been in operation for several years, and no extensive new developments were reported in 1916.

GEORGIA.

Georgia ranked seventh in quantity and fifth in value of pyrite marketed in 1916 as in 1915, although it increased its production 1,000 tons in quantity and $10,000 in value in 1916. The only two properties reported in operation were the mine of the Sulphur Mining & Railroad Co., in Carroll County, and the mine of the Standard Pyrites Co., in Cherokee County. Several of the idle mines, however, were being examined with a view to reopening to take advantage of the high prices paid for pyrite.

ILLINOIS.

Illinois ranked fourth in both quantity and value of pyrite produced and sold in 1916. All this material was won in the course of coal-mining operations, and a large part of the so-called pyrite was

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really marcasite. The production of the State was about 20,000 tons, valued at more than $50,000, an increase of about 5,000 tons in quantity and of nearly $30,000 in value, compared with 1915. The pyrite found in association with coal was formerly thought to be a worthless or injurious material that must be discarded. Recently, however, it has been recognized to have considerable value, and this has led to the increased production. As this knowledge becomes more and more widespread, a still further saving and utilization of this material is to be expected.

Ten mines reported their production, eight, Hume & Spangler, Danville Colleries Coal Co., Central Coal Co., Western Coal Co., Contract Mining Co., Wm. J. Watkins, Carbon Hill Coal Co., and Edward Evans, in Vermilion County; one, the Madison Coal Corporation, in Madison County, and one, the J. H. Milan mine, in Knox County.

INDIANA.

The pyrite produced in Indiana is gained entirely from the iron sulphide recovered in connection with the coal-mining industry. Most of the sulphide is marcasite rather than pyrite. The output in 1916 was about 200 tons less than that of 1915 and was obtained entirely from Vigo County, in the west-central part of the State.

The following mines reported production: Vandalia Coal Co., Isaac Craft, Sunbeam Coal Co., and Sugar Valley Coal Co.

MASSACHUSETTS.

No production of pyrite was reported from Massachusetts for 1916. The increased activity in searching for pyrite deposits has led to some talk of reopening the pyrite mines in the northwestern part of the State, but so far as learned no active steps had been taken toward this end before the close of the year.

MISSOURI.

The production of pyrite in Missouri in 1916 showed a slight increase in quantity but a slight decrease in value. The production came entirely from two mines—the Empire Carbon Works, near Bourbon, in Crawford County, and the Beulah Mining Co.'s mine, near Morrellton, in Franklin County.

NEW YORK.

New York ranked third among the States in 1916 in both quantity and value of the pyrite produced. In 1916 pyrite came from two localities, both in St. Lawrence County, the mine of the St. Lawrence Pyrite Co. and the mine of the Northern Ore Co. The output from both these mines was sold in the form of concentrates. Several of the pyrite mines formerly active remained idle throughout the year.

OHIO.

The production of pyrite in Ohio was 13,551 tons, valued at $36, 114, an increase of nearly 3,000 tons in quantity and of $9,000 in value, compared with 1915. All this material came as a by-product in the

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operation of coal mines. The productive mines were in Tuscarawas, Harrison, and Jefferson counties. The 18 producing mines that reported were as follows: Beech Flats Coal Co., Glens Run Coal Co., New Philadelphia Coal & Mining Co., Midvale Coal Co. (2 plants), Van Kirk Coal & Mining Co., Bucher & Brick Coal Co., George Dean, Goshen Central Coal Co., The James Mullins Coal Co., Reeves Coal Co., Herman C. Schneider, Horger & Heldt Coal Co. (2 plants), Stillwater Coal Mining Co., Indian Hill Coal Co., and Wheeling & Lake Erie Coal Mining Co. (2 plants).

PENNSYLVANIA.

Only one mine reported a production of pyrite in Pennsylvania in 1916. This was the Cascade Coal & Coke Co., in Clearfield County.

SOUTH CAROLINA.

In South Carolina the old Haile gold mines have been reopened as pyrite mines, and a considerable output was reported by the operator, A. K. Blakeney. This was the only production of pyrite reported from South Carolina.

SOUTH DAKOTA.

Three small shippers of pyrite ore reported from South Dakota. Most of this ore was shipped East for treatment, and the high cost of railroad transportation practically absorbed any profit from the ore. The producers reporting were R. L. Hull and H. M. Francis, Pennington County, and the Cuyahoga Mining Co., of Custer County.

TENNESSEE.

Two producers reported a small quantity of pyrite recovered in coal-mining operations in Tennessee. These were the Brier Hill Collieries, in Overton County, and the Fentress Coal & Coke Co., in Fentress County.

VIRGINIA.

Virginia, as usual, ranked first among the States in both quantity and value of pyrite in 1916, the marketed production being 148,502 long tons, valued at $925,243. This quantity was but little in excess of the output in 1915, the relatively small increase being due to the fact that the shaft of one of the larger producers caved early in February, and that consequentiy the mine was out of commission during the larger part of the year. The value of the pyrite was nearly $200,000 greater than in 1915, owing to the increased demand and high price for pyrite in the eastern United States. Five operators produced pyrite during the year. They were the General Chemical Co., in Carroll County; the Sulphur Mining & Railroad Co., the Boyd-Smith mine, and the Arminius Chemical Co., all in Louisa County; and the Cabin Branch Mining Co., in Prince William County. Several of the mines that were idle during 1916 reported that prospecting operations had been undertaken with a view to reopening the properties in the near future.

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WISCONSIN.

The statistics of pyrite or marcasite produced in southwestern Wisconsin and northwestern Illinois are combined in this report and are also credited to Wisconsin because nearly all the production comes from Wisconsin and because ordinarily it is impossible to differentiate the production of the two States, a condition caused by the fact that low-grade blende containing marcasite usually originates in both States and is shipped to separating plants, after which it becomes impossible to credit accurately the original State producing it. Part of this pyrite is obtained with the zinc ores mined in the southwestern part of Wisconsin in what is generally known as the Wisconsin or upper Mississippi Valley zinc district, which includes also Illinois and Iowa, though no zinc ore was produced in Iowa in 1916. The zinc sulphide and the iron sulphide from both States was separated by the National Zinc Separating Co., in Lafayette County, and the Vinegar Hill Zinc Co., at Livingston, in Grant County, both in Wisconsin. Many of the other separating plants that have formerly been active were idle or reported no production of pyrite during 1916.

IMPORTS.

The imports of pyritic ore showed a notable increase during 1916 and were the greatest in the history of the industry. The following table gives the statistics for 1916, as well as for several preceding years:

Pyrite containing more than 25 per cent of sulphur imported for consumption in the United States, 1911–1916.

Year.	Quantity (long tons).	Value.	Year.	Quantity (long tons).	Value.
1911	1,006,310	$3,788,803	1914	1,026,617	$4,797,326
1912	970,785	3,841,683	1915	964,634	4,817,977
1913	850,592	3,611,137	1916	1,244,662	6,728,318

The distribution of the imported pyrite by ports of entry is shown by the table on page 426, the statistics for which were obtained from the Bureau of Foreign and Domestic Commerce, Department of Commerce. From this table it will be seen that 148,682 long tons, valued at $570,768, were received at ports near the Canadian boundary and presumably came from deposits in Canada. The average value of this ore appears to have been approximately $3.84 a long ton. The remainder of the imported ore—1,095,980 tons, valued at $6,157,550—appears to have come entirely from Spain and Portugal and to have had an average value of $5.62 a long ton. It is evident that if shipments of pyritic ore across the Atlantic are curtailed or stopped, the quantity of ore that would have to be replaced in part or wholly by domestic pyrite or sulphur is represented by the imports from Spain and Portugal.

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Pyrites containing more than 25 per cent of sulphur imported for consumption in the United States, 1913–1916.

Customs district.	1913		1914		1915		1916	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
Georgia	85,258	$370,391	82,943	$381,461	54,631	$233,778	120,454	$454,080
Maryland	161,565	985,381	160,631	979,661	181,717	1,046,724	221,440	1,368,988
Massachusetts	31,343	107,576	52,512	216,827	59,657	227,602	61,075	234,963
New York	163,290	633,885	173,224	596,637	154,292	564,088	181,189	662,042
North Carolina	31,253	113,174	34,239	134,255	25,093	123,150	44,473	155,592
Philadelphia	135,756	482,052	181,178	1,256,820	194,521	1,464,750	276,757	2,457,912
South Carolina	64,554	254,419	89,410	351,411	64,712	242,001	99,987	392,844
Virginia	14,620	81,268	16,983	90,565	16,324	107,247	20,028	132,934
Florida	38,838	126,755	20,661	87,667	28,358	104,229	49,202	169,078
Mobile	43,077	144,032	55,813	193,451	49,599	167,008	8,984	31,441
New Orleans	13,650	53,138	17,502	61,846	12,573	51,675	12,391	47,676
San Francisco					270	3,505		
Washington, D. C.					201	3,147		
Buffalo	13,300	63,840	19,015	92,184	27,140	124,925	37,186	136,649
Chicago	16,750	80,500	36,750	176,160	27,400	122,300	41,700	192,750
Michigan			2,225	11,290	3,808	18,665	1,414	6,670
Ohio	10,350	49,680	48,145	80,355	26,800	120,600	40,733	168,118
Vermont	26,988	65,046	35,386	86,736	37,538	91,883	27,649	66,581
	850,952	3,611,137	1,026,617	4,797,326	964,634	4,817,977	1,244,662	6,728,318

SULPHURIC ACID.

CONDITION OF THE INDUSTRY.

The use of sulphuric acid has long been recognized as affording a reliable index of national activities, for this material is essential to almost all the industries. Under the conditions imposed by the war an enormously increased demand has developed, and never before has so much sulphuric acid been consumed in the country. So urgent has been the need for this acid that it has been difficult for the producers to supply enough, and prices have been greatly increased. The increase in price, however, has been due in large measure to the increased cost of raw materials and labor, so that the excess in value of the acid produced in 1916 over the value of the acid produced in 1915 does not represent increased profits to the acid producers.

One of the notable results of the year has been the increased demand for sulphuric acid of the highest strengths. This has been met in large measure, but the market for greater quantities of strong acid has by no means been fully satisfied. According to Phalen,[1] "ordinary concentration plants for producing the strongest grades of acids may be built in a comparatively short time, but not plants designed for the production of acid itself." The need of increasing the output to meet the anticipated demand therefore requires the the outlay of a large amount of capital considerably in advance of the time of actual need for the acid. Many acid manufacturers throughout the country have recognized this need, and new plants are being built and put into commission as early as possible.

As a result of the stimulation of the industry by the high prices and by the large demand many of the manufacturers of acid are having difficulty in getting sufficient supplies of sulphur ore. As a consequence, many of the manufacturers that formerly used pyrite have been forced to substitute native sulphur. The use of this prac-

[1] Phalen, W. C., Sulphur, pyrite, and sulphuric acid: U. S. Geol. Survey Mineral Resources, 1915, pt. 2, p. 303, 1917.

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tically pure material to make acid for the poorer grades should be discouraged until it can be definitely proved that domestic sulphide supplies can not be developed to meet the demand. The domestic supply supplemented by some foreign pyrite is believed to be adequate, and the present seems a particularly fortunate time to develop domestic supplies of pyrite that may replace in constantly growing measure the present large imports of foreign ore. The successful development of such an industry would mark one more step in the progress of making America industrially independent.

USES.

Sulphuric acid is probably used in a greater variety of ways in the chemical arts than any other substance. According to Lunge,[1] the principal applications of the acid are as follows:

1. *In a more or less dilute state (say from 144° Twad. downward).*—For making sulphate of soda (salt cake) and hydrochloric acid, and therefore ultimately for soda ash, bleaching powder, soap, glass, and innumerable other products. Further, for superphosphates and other artificial manures. These two applications probably consume nine-tenths of all the sulphuric acid produced. Further applications are for preparing sulphurous, nitric, phosphoric, hydrofluoric, boric, carbonic, chromic, oxalic, tartaric, citric, acetic, and stearic acids; in preparing phosphorus, iodine, bromine, and sulphates of potassium, ammonium, barium (blanc fixe), calcium (pearl-hardening); especially also for precipitating baryta or lime as sulphates for chemical processes; sulphates of magnesium, aluminum, iron, zinc, copper, mercury (as intermediate stage for calomel and corrosive sublimate); in the metallurgy of copper, cobalt, nickel, platinum, silver; for cleaning (pickling) sheet iron to be tinned or galvanized; for cleaning copper, silver, etc.; for manufacturing potassium bichromate; for working galvanic cells, such as are used in telegraphy, in electroplating, etc.; for manufacturing ordinary ether and the composite ethers; for making or purifying many organic coloring matters, especially in the oxidizing mixture of potassium bichromate and sulphuric acid; for parchment paper; for purifying many mineral oils, and sometimes coal gas; for manufacturing starch, sirup, and sugar; for the saccharification of corn; for neutralizing the alkaline reaction of fermenting liquors, such as molasses; for effervescent drinks; for preparing tallow previously to melting it; for recovering the fatty acids from soapsuds; for destroying vegetable fibers in mixed fabrics; generally in dyeing, calico printing, tanning; as a chemical reagent in innumerable cases; in medicine against lead poisoning, and in many other cases.

2. *In a concentrated state.*—For manufacturing the fatty acids by distillation; purifying colza oil; for purifying benzene, petroleum, paraffin oil, and other mineral oils; for drying air, especially for laboratory purposes, but also for drying gases for manufacturing processes (for this, weaker acid also, of 140° Twad., can be used); for the production of ice by the rapid evaporation of water in a vacuum; for refining gold and silver, desilvering copper, etc.; for making organo-sulphonic acids; manufacturing indigo; preparing many nitric compounds and nitro ethers, especially in manufacturing nitroglycerin, pyroxylin, nitrobenzene, picric acid, etc.

3. *As Nordhausen fuming oil of vitriol (anhydride).*—For manufacturing certain organo-sulphonic acids (in the manufacture of alizarin, eosin, indigo, etc.); for purifying ozokerite; for making shoe blacking; for bringing ordinary concentrated acid up to the highest strength as required in the manufacture of pyroxylin; and for other purposes.

The most important of the classes of manufacture enumerated above, so far as the consumption of the acid is involved, are (1) the manufacture of fertilizers; (2) the refining of petroleum products; (3) the iron, steel, and coke industries; (4) the manufacture of nitrocellulose, nitroglycerin, celluloid, etc.; and (5) general metallurgic and chemical practice.

[1] Lunge, Manufacture of sulphuric acid and alkali, vol. 1, pt. 2, pp. 1169–1170, 1903.

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According to Utley Wedge, of Ardmore, Pa.,[1] the amount of 50° Baumé sulphuric acid consumed in the United States for various purposes during normal years is as follows:

	Short tons.
Fertilizers	2,400,000
Petroleum	300,000
Iron, steel, and coke industries	200,000
Explosives (pre-war conditions)	150,000
All other industries	200,000
	3,350,000

PRODUCTION.

GENERAL STATEMENT.

The production of sulphuric acid in 1916, expressed in terms of acid of a strength of 50° B., was 5,642,112 short tons, valued at $62,707,369, to which must be added 443,332 short tons of acid of strengths higher than 66° B., not convertible into acid of 50° B., valued at $10,806,757. The total value of all the sulphuric acid was therefore $73,514,126. This production shows an increase over the production of 50° B. acid in 1915 of nearly 2,000,000 short tons in quantity and of nearly $34,000,000 in value; and an increase in stronger acids of more than 250,000 short tons in quantity and $8,000,000 in value.

Sulphuric acid produced in the United States in 1914, 1915, and 1916.

Grade.	1914			1915			1916		
	Quantity (short tons).	Value.	Price per ton.	Quantity (short tons).	Value.	Price per ton.	Quantity (short tons.)	Value.	Price per ton.
50° Baumé	1,628,402	$9,712,056	$5.96	[a]1,518,271	$10,681,246	$7.04	1,829,471	$17,484,273	$9.55
60° Baumé	551,955	3,376,242	6.12	657,076	4,976,453	7.57	1,119,753	12,362,884	11.04
66° Baumé	916,192	10,509,471	11.47	1,019,024	14,211,381	13.95	1,580,100	32,860,212	20.80
Stronger acids	65,890	882,158	13.39	[b]189,795	2,787,971	14.69	443,332	10,806,757	24.38
	3,162,439	24,479,927	7.74	3,384,166	32,657,051	9.65	4,972,656	73,514,126	14.79
Total reduced to 50° Baumé	[c]3,762,417	[d]24,163,331	[d]6.42	[d]3,868,152	[d]29,869,080	[d]7.72	[d]5,642,112	[d]62,707,369	[d]11.11

[a] Includes not only acid reported as 50°, but also 52°, 53°, and 55° acid reduced to the equivalent.
[b] Includes stronger acid reported as oleum, etc., carrying varying percentages of free SO_3.
[c] Exclusive of 21,993 short tons of fuming acid, not convertible, valued at $316,596.
[d] Exclusive of "stronger acids."

The totals given above include by-product acid—that is, acid produced at copper and zinc smelters. The production of acid from this source in 1916, expressed in terms of 60° acid, was 1,069,589 short tons, valued at $12,158,266, to which must be added 92,802 short tons of acid of strengths higher than 66° B., not convertible into acid of 60° B., valued at $1,941,661. None of the stronger acids are reported to have been produced at copper smelters, and no 50° acid was reported to have been produced at the zinc smelters.

[1] Royal Ontario Nickel Commission Rept., pp. 491, Toronto, 1917.

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PRODUCTION AT COPPER AND ZINC SMELTERS.

Sulphuric acid produced at copper and zinc smelters, 1913–1916.[a]

[Reduced to 60° Baumé acid.]

Source.	1913			1914		
	Quantity (short tons).	Value.	Price per ton.	Quantity (short tons).	Value.	Price per ton.
Copper smelters	336,019	$2,205,627	$6.56	348,727	$2,215,690	$6.25
Zinc smelters	296,218	2,140,645	7.23	411,911	2,974,603	7.22
	632,237	4,346,272	6.87	760,638	5,190,293	6.82
Total reduced to 50° Baumé	790,296			950,798		

Source.	1915			1916		
	Quantity (short tons).	Value.	Price per ton.	Quantity (short (tons).	Value.	Price per ton.
Copper smelters	360,522	$2,749,633	$7.63	398,004	$3,988,615	$10.02
Zinc smelters	484,942	4,292,493	8.85	671,585	8,169,651	12.16
Stronger acids[b]	59,189	579,115	9.78	92,802	1,941,661	20.92
	904,653	7,621,241	8.42	1,162,391	14,099,927	12.13
Total reduced to 50° Baumé	[c] 1,056,830			[c] 1,347,082		

[a] The acid reported to the Survey includes that of 50°, 53°, 55°, 60°, and 66° Baumé strengths, and a small quantity of electrolyte and oleum. All strengths, with the exception of the electrolyte, have been reduced to both 50° and 60° Baumé, as given in the table.

[b] Includes stronger acid reported as oleum, etc., carrying varying percentages of free SO_3.

[c] Exclusive of "stronger acids."

PRODUCTION BY STATES.

In the following table the production of sulphuric acid by States, so far as it can be given without disclosing the output of individual plants, is stated.

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Production of sulphuric acid in 1916, by States.

State.	Number of producing plants.					Quantity (short tons).		
	Total.	50° B.	60° B.	66° B.	Stronger.	50° B.	60° B.	66° B.
Alabama	12	10	2	2		112,025	[b] 60,345	(b)
Arkansas	1		1				(a)	
California	8	[a] 5	3	4	2	(a)	14,060	105,786
Colorado	2		1	1	2		(a)	(a)
Connecticut	2	1	1	2		(a)	(a)	(a)
Delaware	1			1				(a)
Florida	5	5	1			[b] 50,524	(b)	
Georgia	30	28	10	6		284,447	44,158	21,878
Illinois	11	1	10	4	2	(b)	[b] 287,225	78,734
Indiana	2	1		1	1	(a)		(a)
Kansas	1		1	1			(a)	(a)
Louisiana	3	3	1			[b] 28,102	(b)	
Maryland	11	10	2	3	1	309,334	(b)	[b] 117,632
Massachusetts	4	4	1	2	1	[b] 209,659	(b)	(b)
Michigan	4	2	2	2		[b] 45,216	(b)	(b)
Mississippi	5	5	3			31,100	12,498	
Montana	2		1		1		(a)	
New Jersey	17	9	4	8	5	110,192	17,266	380,995
New York	6	2	2	3	2	(b)	(b)	[b] 93,850
North Carolina	12	11		1		[b] 146,054		(b)
Ohio	14	6	5	6	1	81,941	28,036	149,737
Oklahoma	1		1	1			(a)	(a)
Pennsylvania	20	7	12	16	5	170,440	229,850	248,439
South Carolina	15	13	4	1		194,487	[b] 30,425	(b)
Tennessee	6	2	5	2		(b)	[b] 281,815	(b)
Texas	3	1		2		(b)		[b] 16,763
Utah	1			1				(a)
Virginia	9	8	1	2	1	[b] 215,638	(b)	(b)
Washington	1				1			
Wisconsin	2		1	1	2		(a)	(a)
Undistributed	15	7	7	9	6	22,899	85,304	290,033

[a] Carried in "Undistributed," which includes Arkansas, Colorado, Connecticut, Delaware, Indiana, Kansas, Montana, Oklahoma, Utah, Wisconsin, and 50° acid from California.
[b] Acid of this strength produced, but figures consolidated with those of another strength of acid and recalculated.

In the statement regarding the number of plants producing acid of different strengths, it should be noted that inasmuch as a single plant may produce acid of 50°, 60°, 66°, and higher strengths it may be tabulated under each of the appropriate columns, so that to find the number of actual plants in operation the first column should be consulted.

The production of acids stronger than 66° Baumé was reported by 27 plants situated in 14 different States. Only in the States of New York and Pennsylvania were there more than two plants. In order not to disclose confidential information regarding the individual plants it has consequently been necessary to consolidate the statements regarding the quantity and value of the production of the acids of higher strengths and publish only statistics regarding the total production. The total production of sulphuric acid of strength greater than 66° Baumé was 443,332 short tons, valued at $10,806,757. The average value of this acid was about $24.38 a short ton.

IMPORTS.

Very little sulphuric acid is at any time imported into the United States, and in 1916 over 99 per cent of the acid received was entered at Buffalo, evidently having been manufactured in the near-by parts of Canada. This quantity was considerably less than had been received from this same source in the years immediately preceding, and the decrease was undoubtedly due to the greatly increased consumption in Canada of acids for the manufacture of munitions.

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Sulphuric acid imported for consumption in the United States, 1913–1916.

Customs district.	1913		1914		1915		1916	
	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.
Buffalo	1,200,439	$7,483	6,781,721	$39,455	8,333,935	$62,401	1,406,160	$20,434
Genesee	255	6						
Maine and New Hampshire					50	3	60	9
Michigan	749,280	4,492	1,128,420	6,306	1,050,750	7,479		
New York City	310	10					1,548	1,024
Philadelphia	88	1			262	25		
St. Lawrence			5	5	364	12		
Vermont							4,392	203
Washington							1	2
	1,950,372	11,992	7,910,146	45,766	9,385,361	69,920	1,412,161	21,672
Equivalent in short tons.	975		3,955		4,693		706	

EXPORTS.

The exports of sulphuric acid during the last four years, according to the Department of Commerce, have been as follows:

Sulphuric acid exported from the United States, 1913–1916.

Year.	Quantity (short tons).	Value.
1913	4,484	$103,725
1914	6,588	140,375
1915	38,919	998,249
1916	33,231	1,847,995

ORES USED FOR MANUFACTURE OF ACID.

For the production of all the grades of sulphuric acid in 1916 the following quantities and kinds of sulphur ore were used:

Sulphur and ore used in the manufacture of sulphuric acid in 1916, in long tons.

	Sulphur.	Pyrite and pyrrhotite.	Gold and silver-bearing pyrite.	Copper-bearing sulphides.	Zinc-bearing sulphides.
Domestic	261,574	324,602	1,673	568,116	531,625
Foreign	10,903	1,154,550		196,404	92,002
	272,477	1,479,152	1,673	764,520	623,627

In the column headed "Pyrite and pyrrhotite" are tabulated all the sulphide ores used which are not treated further for their copper, lead, zinc, gold, or silver content. Much of this material doubtless contains small quantities of these metals, but inasmuch as they are not recovered their presence in the ore is of no economic importance.

In the eastern third of the country—that is, in the area extending westward from the Atlantic Ocean to include Alabama, Tennessee, and other parts of the Appalachian Mountains, but not Ohio—approximately 200,000 tons of domestic sulphur, 7,000 tons of foreign sulphur, 200,000 tons of domestic pyrite and pyrrhotite, and more than 1,010,000 tons of foreign pyrite were used in the manufacture of acid. In the central part of this country, extending westward from the Appalachians and including the States of Montana and Colorado, approximately 62,000 tons of domestic sulphur, 1,300 tons of foreign sulphur, 80,000 tons of domestic pyrite, and 145,000 tons of foreign pyrite were used in the manufacture of acid. In the Pacific Coast States, including Utah, less than 700 tons of native sulphur, 2,500 tons of foreign sulphur, 49,000 tons of domestic pyrite, and no foreign pyrite were used in the manufacture of acid.

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LIME,

By G. F. Loughlin.[1]

INTRODUCTION.

On January 12, 1917, a preliminary estimate of the total quantity of lime sold in 1916 was published. This was the first time that such an estimate had been attempted, but it proved to be only 76,567 short tons, or 1.9 per cent, in excess of the final figures. An estimate of the quantity of the hydrated lime marketed in 1916 proved to be 7,382 short tons, or 1 per cent, below the final figures.

In spite of the early publication of this estimate, however, the final report has been published later than usual, owing in part to slowness of returns from producers and in part to added work resulting from the war.

In this report are published for the first time a separate statement of the production of marl, a table showing the marketed production of hydrated lime by States, and a table showing the consumption of lime by States. The table of consumption is based on returns representing more than 99 per cent of the total production.

LIME SOLD IN 1916.

The total quantity of lime sold in 1916 was 4,073,433 short tons, valued at $18,509,305—an increase over the revised figures for 1915 of 450,623 tons, or more than 12 per cent, in quantity and of $4,085,269, or 28 per cent, in value. This was the first year in which the lime marketed in the United States equaled or exceeded 4,000,000 tons, as is shown in the accompanying table.

Lime burned and sold in the United States in 1907–1916.

	Quantity (short tons).	Value.[a]	Average price per ton.	Number of plants in operation.
1907	3,092,524	$12,656,705	$4.09	899
1908	2,766,873	11,091,186	4.01	949
1909	3,484,974	13,846,072	3.98	1,232
1910	3,505,954	14,088,039	4.02	1,125
1911	3,392,915	13,689,054	4.03	1,139
1912	3,529,462	13,970,114	3.96	1,017
1913	3,595,390	14,648,362	4.07	1,023
1914	3,380,928	13,268,938	3.92	954
1915	[b] 3,622,810	[b] 14,424,036	[b] 3.98	[b] 906
1916	4,073,433	18,509,305	4.54	778
Percentage of increase in 1916	12.4	28.3	.....	.....

[a] The value given represents the value of bulk lime f. o. b. at point of shipment and does not include weight or cost of barrel or package.

[b] Revised.

[1] The statistical tables of this report were prepared by Miss A. T. Coons, with the exception of those on imports and exports, which were compiled by J. A. Dorsey, both of the United States Geological Survey.

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The record would have been even greater had it not been for high cost of supplies, scarcity of labor, strikes, scarcity of railway cars in many parts of the country, and lack of fuel. The labor situation throughout the year is well summarized in the following statement:[1]

Advance labor cost is felt in every quarry operation with increasing effect. In many places quarry labor is double the price it was one year ago. Only those operators who were wise enough to put in mechanical tools to displace labor can now operate profitably upon a large scale. High labor costs have automatically advanced the selling price of every commodity dependent upon quarry operations for the supply of raw materials. This is inevitable, and the mill prices of all the staple building materials have been affected to that extent, plus another heavy increased item due to excessive advances in all kinds of mill supplies and repair parts for machinery. Building materials is the only line in which the advances in prices have all been warranted and logical with the actual cost basis of production.

In spite of the high cost of production, however, there were some interesting new developments in 1916. The Vermont Marble Co., Proctor, Vt., put into operation a rotary kiln and hydrating plant described as the most modern plant of its kind in existence.[2] The Charles Warner Co. put into service a new lime-manufacturing plant near Devault, Pa., adjacent to its Cedar Hollow plant. This plant is equipped with a crusher and screen building for reducing quarry stone to a size suitable for rotary kiln; bin storage and ground storage for reserve; rotary kiln with shell 8 feet by 150 feet fired by producer gas, with a normal capacity of 100 tons of stone daily; a rotary cooler; quicklime pulverizing plant, with storage capacity of 6,000 tons for making pulverized quicklime of a quality suitable for the agricultural trade and for further finer pulverizing for subsequent hydration; hydrating plant, with daily capacity of 325 tons (hydrate seasoned three days before finishing); finishing building for the hydrated lime; building for packing and storage of empty bags. In addition to the foregoing, there is a department for making finely pulverized limestone for the agriculture, chemical, and road-building trades.

Near Latrobe, Eldorado County, Cal., the Eldorado Limestone Co. completed construction of two kilns, with a capacity of 40 short tons of lime a day. A branch line was built from the quarry to the Southern Pacific Railroad, and derricks, hoists, and grinders were installed at the quarry.

In addition to the limestone burned by the producers themselves a quantity of limestone is sold each year by producers to burners of lime in small kilns; furthermore, limestone quarried in Ohio is shipped in considerable quantity to Wisconsin and Minnesota to be burned into lime. The quantity of limestone thus sold in 1916 was 130,729 short tons, valued at $81,473, equivalent to about 68,000 tons of burned lime. As these sales represent limestone produced and sold as stone, their quantity and value are tabulated in the report on stone.

A considerable quantity of limestone sold by quarrymen to sugar refineries, smelters, and alkali works and burned at those plants is also tabulated in the stone report, but the figures are repeated here in the section on "Uses."

[1] Rock Products and Building Materials, June 22, 1916, p. 19.
[2] Met. and Chem. Engineering, July 1, 1916, pp. 50–51.

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The increase in output was accompanied by the greatest increase in average price per ton ever recorded by the United States Geological Survey—an increase due both to greater demand and to greater cost of fuel and labor. These same causes account largely for the decrease of 128 in the number of active plants, which in 1916 was 778, the lowest ever recorded by the Survey. The decrease was principally among the small producers in Pennsylvania, where there were 116 fewer operators active in 1916 than in 1915. The number of kilns in operation increased from 2,340 in 1915 to 2,341 in 1916.

There was increase in average price per ton in all but eight States, which were for the most part widely scattered. Maine and Maryland were the only Atlantic States and Kentucky, Iowa, and Oklahoma, all small producers, were the only Central States to show decrease. In the Pacific coast region California and Washington showed decrease, as did Arizona, whose principal market is southern California. As several producers in California and Washington continued to complain of price cutting, this may have been a large contributing cause to the continued decline in price in these States. The largest decreases in average price per ton in 1916 were in Oklahoma ($1.37) and California (60 cents). The largest increases in price per ton in important States were in Connecticut ($2.08) and Wisconsin ($1.10); in Idaho, South Dakota, and Oregon the increases were, respectively, $1.51, $1.46, and $1.09; and in Hawaii and Porto Rico $3.83 and $1.81.

In 1916 sales of lime were reported from 42 States—one less than in 1915. Georgia and South Carolina, each represented by one active plant in 1915, were not represented in 1916, but Kansas rejoined the list of producing States, with two active plants. Of the 42 States all but 8 showed increase in quantity and value of lime sold in 1916. Illinois, Minnesota, and Florida, with a small decrease in quantity, showed increase in value. These States ranked fifteenth, twenty-first, and twenty-sixth in quantity, respectively. Of the five States showing decrease in both quantity and value, the largest producers were California and Washington, which ranked seventeenth and twentieth in quantity, respectively.

The seven leading States in quantity of lime sold were the same in 1916 as in 1915—Pennsylvania, Ohio, Virginia, West Virginia, Wisconsin, Missouri, and Maine. Pennsylvania, with 972,343 tons, and Ohio, with 570,972 tons, were far ahead of the other States; Virginia, West Virginia, and Wisconsin exceeded 250,000 tons; and seven other States exceeded 100,000 tons. The rank in value in 1916 was as follows: Pennsylvania, Ohio, Virginia, Wisconsin, West Virginia, Maine, and Missouri. Virginia advanced from fifth to third place and Wisconsin from sixth to fourth; Maine dropped from third to sixth place and West Virginia from fourth to fifth. Pennsylvania for the first time exceeded $3,000,000 and Ohio $2,000,000. Wisconsin, which barely exceeded $1,000,000 in 1913 and was below that figure in 1914 and 1915, exceeded $1,200,000. Virginia and West Virginia exceeded $1,000,000 for the first time.

The lime sold in Pennsylvania in 1916 amounted to 24 per cent of the total quantity, compared with 25 per cent in 1915, and to 21 per cent of the total value, the same as in 1915; that sold in Ohio in 1916, as in 1915, amounted to about 14 per cent of both the total quantity

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and the total value. The output from Ohio, however, was produced by 34 plants, 7 less than in 1915, whereas that from Pennsylvania came from 335 operators, compared with 451 in 1915. The operators in Pennsylvania in 1916 included 267 farmers, who burned lime in stack kilns for local use, and small producers, who sold to farmers, and this total local production amounted to 117,024 tons, valued at $286,382, or $2.45 a ton. Exclusive of this local production, Pennsylvania's sales in 1916 amounted to 855,319 tons, valued at $3,571,171, or $4.17 a ton, from 68 producers. This quantity also includes the output of some large producers who sell mainly to farmers at low prices. A considerable quantity of low-priced lime is also burned in small lots for agricultural use in Maryland, Virginia, and West Virginia.

Lime burned and sold in the United States in 1915 and 1916.

1915.

State or Territory.	Rank of State by quantity.	Quantity (short tons).	Value.	Rank of State by value.	Average price per ton.	Number of plants in operation.
Alabama	16	60,332	$250,227	17	$4.15	14
Arizona	23	14,137	90,931	22	6.43	3
Arkansas	22	15,879	78,112	23	4.92	8
California	17	57,292	431,424	10	7.53	18
Colorado	32	4,647	29,131	32	6.27	5
Connecticut	15	76,022	368,343	13	4.85	6
Florida	26	b 9,243	b 47,920	27	5.18	4
Georgia	42	(a)	(a)	43	2.50	1
Hawaii	29	(a)	(a)	25	9.32	1
Idaho	35	3,357	19,247	35	5.73	4
Illinois	12	88,604	352,954	14	3.98	14
Indiana	11	99,916	374,221	12	3.74	8
Iowa	27	(a)	(a)	26	5.12	3
Kentucky	39	1,307	7,070	39	5.41	9
Maine	7	146,400	945,108	3	6.46	4
Maryland	9	b 130,597	409,588	11	3.69	21
Massachusetts	8	135,580	669,629	8	4.94	10
Michigan	14	81,359	349,979	15	4.31	10
Minnesota	21	20,359	96,190	21	4.72	5
Missouri	6	b 155,501	b 691,042	7	4.44	22
Montana	33	(a)	(a)	34	6.00	3
Nevada	28	(a)	(a)	28	6.50	1
New Jersey	25	10,273	35,393	29	3.45	10
New Mexico	38	1,760	11,963	38	6.96	4
New York	10	115,861	575,384	9	4.97	25
North Carolina	30	(a)	(a)	33	4.92	2
Ohio	2	507,993	1,954,810	2	3.85	41
Oklahoma	40	(a)	(a)	40	7.72	2
Oregon	34	4,188	30,411	31	7.26	4
Pennsylvania	1	901,549	2,947,058	1	3.27	451
Porto Rico	36	3,118	16,983	37	5.45	23
Rhode Island	37	(a)	(a)	36	7.00	1
South Carolina	41	(a)	(a)	41	3.33	1
South Dakota	31	5,625	34,728	30	6.17	3
Tennessee	13	82,765	256,069	16	3.09	14
Texas	18	39,468	211,516	18	5.36	10
Utah	24	11,460	67,273	24	5.87	10
Vermont	19	37,992	187,144	19	4.93	8
Virginia	3	267,278	840,969	5	3.15	40
Washington	20	27,240	171,023	20	6.28	8
West Virginia	4	250,000	896,520	4	3.59	26
Wisconsin	5	221,147	755,986	6	3.42	35
Wyoming	43	(a)	(a)	42	12.50	1
Undistributed		34,601	219,690			
		b 3,622,810	b 14,424,036		3.98	908

a Included in "Undistributed." b Figures for 1915 revised in 1916.

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Lime burned and sold in the United States in 1915 and 1916.

1916.

State or Territory.	Rank of State by quantity.	Quantity (short tons).	Value.	Rank of State by value.	Average price per ton.	Number of plants in operation.
Alabama	16	67,524	$312,531	17	$4.63	9
Arizona	23	15,173	94,540	23	6.23	3
Arkansas	22	19,199	102,683	22	5.35	4
California	17	56,820	393,930	13	6.93	15
Colorado	31	5,479	36,473	31	6.66	6
Connecticut	14	85,063	589,257	10	6.93	7
Florida	26	8,666	49,536	25	5.71	4
Hawaii	36	(a)	(a)	30	13.15	1
Idaho	33	4,389	31,786	34	7.24	3
Illinois	15	80,012	369,038	16	4.61	12
Indiana	10	121,306	495,283	12	4.08	8
Iowa	25	(a)	(a)	26	5.00	2
Kansas	41	(a)	(a)	41	3.98	2
Kentucky	40	1,236	6,304	40	5.10	9
Maine	7	162,100	956,371	6	5.90	4
Maryland	8	157,673	574,998	11	3.65	36
Massachusetts	9	145,020	811,402	8	5.60	10
Michigan	13	86,447	385,341	14	4.46	7
Minnesota	21	20,150	103,000	21	5.11	5
Missouri	6	199,260	956,300	7	4.80	32
Montana	29	(a)	(a)	28	6.29	2
Nevada	31	(a)	(a)	33	6.52	1
New Jersey	27	7,110	26,084	36	3.67	12
New Mexico	39	1,582	11,670	39	7.38	4
New York	11	117,490	636,668	9	5.42	22
North Carolina	28	(a)	(a)	29	5.50	1
Ohio	2	570,972	2,702,953	2	4.73	34
Oklahoma	37	(a)	(a)	38	6.35	2
Oregon	34	4,225	35,289	32	8.35	5
Pennsylvania	1	972,343	3,857,553	1	3.97	335
Porto Rico	35	3,640	26,436	35	7.26	26
Rhode Island	38	(a)	(a)	37	7.70	1
South Dakota	30	5,772	44,033	27	7.63	4
Tennessee	12	109,533	378,017	15	3.45	17
Texas	18	54,049	307,759	18	5.69	10
Utah	24	12,472	77,133	24	6.18	13
Vermont	19	43,365	236,133	19	5.45	9
Virginia	3	326,812	1,279,658	3	3.88	33
Washington	20	26,895	166,653	20	6.19	8
West Virginia	4	277,721	1,008,021	5	3.63	25
Wisconsin	5	266,805	1,207,059	4	4.52	34
Wyoming	42	(a)	(a)	42	12.62	1
Undistributed	.....	37,130	239,413	.....	.....	.....
	.....	4,073,433	18,509,305	.....	4.54	778

a Included in "Undistributed."

MARL.

A quantity of marl burned or dried for agricultural use, some of which has been formerly included in the lime figures for Arkansas, California, New York, Pennsylvania, South Carolina, and Virginia, is here stated separately for the first time. The total quantity of marl sold for this use in 1916 was 35,588 short tons, valued at $107,768, or $3.03 a ton. Individual reports gave prices ranging from $1 to $3 a ton in the Southern States and from $4 to $6 a ton in the Northern States and California.

UNITS OF MEASUREMENT.

The expression of quantity of lime in short tons in the foregoing tables is a recalculation of the quantities by weight reported by producers. At present there is no standard unit of quantity. Some producers report quantity in bushels, which vary in weight from 40 to

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80 pounds. The number of pounds in a bushel varies with the State in which the lime is sold, and some producers within a single State report various weights per bushel. Where lime is shipped in barrels, the weight per barrel has varied from 160 to 300 pounds and may or may not have included the weight of the barrel itself; but the figures in this report represent, almost without exception, the net weight of the lime sold.

Opposition among lime producers, especially the National Lime Manufacturers' Association, to the bill (H. R. 4899, 1st sess. 63d Cong.) fixing the dimensions of the standard barrel for dry commodities, caused the passage of the following act (S. 5425, 1st sess. 64th Cong.):

AN ACT To standardize lime barrels.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there is hereby established a large and a small barrel of lime, the large barrel to consist of two hundred and eighty pounds and the small barrel to consist of one hundred and eighty pounds, net weight.

SEC. 2. That it shall be unlawful for any person to sell or offer for sale lime imported in barrels from a foreign country, or to sell or offer for sale lime in barrels for shipment from any State or Territory or the District of Columbia, to any other State or Territory or the District of Columbia, unless there shall be stencilled or otherwise clearly marked on one or both heads of the small barrel the figures "180 lbs. net" and of the large barrel the figures "280 lbs. net" before the importation or shipment, and on either barrel in addition the name of the manufacturer of the lime and where manufactured, and, if imported, the name of the country from which it is imported.

SEC. 3. When lime is sold in interstate or foreign commerce in containers of less capacity than the standard small barrel, it shall be sold in fractional parts of said standard small barrel, and the net weight of lime contained in such container shall by stencil or otherwise be clearly marked thereon, together with the name of the manufacturer thereof, and the name of the brand, if any, under which it is sold, and, if imported, the name of the country from which it is imported.

SEC. 4. That rules and regulations for the enforcement of this Act, not inconsistent with the provisions of the Act, shall be made by the Director of the Bureau of Standards and approved by the Secretary of Commerce, and that such rules and regulations shall include reasonable variations or tolerances which may be allowed.

SEC. 5. That it shall be unlawful to pack, sell, or offer for sale for shipment from any State or Territory or the District of Columbia to any other State or Territory or the District of Columbia, any barrels or other containers of lime which are not marked as provided in sections two and three of this Act, or to sell, charge for, or purport to deliver from any State or Territory or the District of Columbia to any other State or Territory or the District of Columbia, as a large or small barrel or a fractional part of said small barrel of lime, any less weight of lime than is established by the provisions of this Act; and any person guilty of a violation of the provisions of this Act shall be deemed guilty of a misdemeanor, and be liable to a fine not exceeding $100.

SEC. 6. That is shall be the duty of each district attorney, to whom satisfactory evidence of any violation of this Act is presented to cause appropriate proceedings to be commenced and prosecuted in the United States court having jurisdiction of such offense: *Provided, however*, That the penal provisions of this Act shall not take effect until January first, nineteen hundred and seventeen.

SEC. 7. That this Act shall be in force and effect from and after its passage.

Approved, August 23, 1916.

At the annual meeting of the National Line Manufacturers' Association in New York, February 6, 1917, it was explained by F. S. Holbrook, of the Bureau of Standards, Department of Commerce, that this law applied only to interstate commerce. He also stated that

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section 3 was intended to apply particularly to hydrated lime but was not wholly satisfactory, and that a substitute for it was being considered. Rules and regulations for the enforcement of the law, referred to in section 4, have been published by the Bureau of Standards in Circular 64, 1917. As the Bureau of Standards is designated as the Federal authority to look after the enforcement of the law, inquiries regarding it should be addressed to that bureau.

USES.

Sales of lime in the different States in 1915 and 1916 classified according to principal uses are shown in the following table. Lime for fluxing, formerly included in "other uses," is shown separately in the columns for 1916, and accounts for the apparent decrease in "other uses." Fluxing together with "other purposes" in 1916 exceeded "other uses" in 1915. Under "Dealers—uses not specified" is included a considerable quantity of lime which the producers could not classify according to uses. This, if distributed, would raise the figures for some of the other uses, especially for building. The marked decrease in quantity and value of lime sold to dealers in 1916 was caused by the fact that producers were better able to specify uses, which accounts also for part of the increase in lime sold for those uses.

Lime sold in the United States in 1915 and 1916 by uses.

	Quantity (short tons).	Value.	Average price per ton.
1915.			
Building lime	[a] 1,149,733	[a] $4,896,990	[a] $4.26
Chemical works	[a] 493,370	[a] 1,656,750	3.36
Paper mills	216,819	782,396	3.61
Sugar factories	34,025	230,368	6.77
Tanneries	47,104	190,864	4.06
Agriculture	[a] 673,260	2,163,574	[a] 3.21
Dealers—uses not specified	595,128	2,508,907	4.22
Other uses [b]	413,371	1,993,887	4.82
	[a] 3,622,810	[a] 14,424,036	[a] 3.98
Hydrated lime (included in total)	581,114	2,457,602	4.23
1916.			
Building lime	1,509,968	7,859,614	5.21
Chemical works	621,120	2,296,246	3.70
Paper mills	353,187	1,461,412	4.14
Sugar factories	21,923	118,572	5.41
Tanneries	59,919	278,003	4.64
Agriculture	613,527	2,224,401	3.63
Fluxing	180,018	712,101	3.96
Dealers—uses not specified	373,011	1,846,730	4.95
Other uses [b]	340,760	1,710,226	5.02
	4,073,433	18,509,305	4.54
Percentage of increase in 1916	12.4	28.3	.....
Hydrated lime (included in total)	717,382	3,626,998	5.06
Percentage of increase in hydrated lime in 1916	23.4	47.6	.....

[a] Revised.
[b] Includes lime for sand-lime brick, slag cement, alkali works, glassworks, sheep dipping, disinfectant, manufacture of soap, cyanide plants, glue factories, purification of water, etc.

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Lime sold in the United States in 1915 and 1916, by States and uses.

1915.

State or Territory.	Building.		Chemical works.		Paper mills.		Sugar factories.		Tanneries.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	13,177	$54,976	1,369	$5,769	(a)	(a)	801	$3,368	(a)	(a)
Arizona	(a)	(a)								
Arkansas	12,526	60,849								
California	12,155	82,252	(a)	(a)	(a)	(a)	16,243	151,945	(a)	(a)
Colorado	1,411	6,946	(a)	(a)			(a)	(a)		
Connecticut	74,956	363,676								
Florida	b 9,243	b 47,920								
Georgia	(a)	(a)								
Hawaii										
Idaho	(a)	(a)	(a)	(a)						
Illinois	40,072	178,716	8,642	32,131	5,991	$24,284	(a)	(a)	(a)	(a)
Indiana	18,649	78,406	10,782	43,034	16,683	57,779	(a)	(a)	5,038	$17,676
Iowa	(a)	(a)								
Kentucky	464	2,735								
Maine	(a)	(a)								
Maryland	7,516	25,225	9,455	20,395						
Massachusetts	81,951	482,015	(a)	(a)	(a)	(a)				
Michigan	1,839	7,168	48,211	212,051	6,043	23,133	610	2,315	4,092	20,100
Minnesota	20,359	96,190								
Missouri	b 51,145	b 261,198	b 20,692	b 83,976	2,750	11,000	880	3,520	784	3,044
Montana	(a)	(a)								
Nevada										
New Jersey	(a)	(a)								
New Mexico	645	4,706								
New York	2,681	12,742	29,100	142,228	20,020	88,574			1,935	17,313
North Carolina					(a)	(a)				
Ohio	182,164	716,591	9,197	32,101	14,155	46,214	(a)	(a)	(a)	(a)
Oklahoma	(a)	(a)								
Oregon	(a)	(a)								
Pennsylvania	284,239	1,049,135	107,407	344,201	50,657	165,135	1,190	3,689	11,804	38,373
Porto Rico	1,260	5,382					952	7,895		
Rhode Island									(a)	(a)
South Carolina										
South Dakota	(a)	(a)	(a)	(a)						
Tennessee	30,689	98,010	(a)	(a)	21,090	59,678	7,790	29,970	786	2,343
Texas	11,713	64,290			(a)	(a)	(a)	(a)	(a)	(a)
Utah	5,100	36,942	(a)	(a)			(a)	(a)		
Vermont	6,420	33,110	12,246	60,745	6,707	31,904	(a)	(a)	8,432	41,560
Virginia	67,050	284,617	122,883	274,208	7,309	29,266	(a)	(a)	5,964	16,055
Washington	17,453	110,216	(a)	(a)	(a)	(a)	(a)	(a)		
West Virginia	(a)	(a)	88,916	298,235						
Wisconsin	123,604	422,097			16,997	59,910			1,351	5,514
Wyoming	(a)	(a)								
Undistributed	71,252	310,880	24,470	101,676	48,417	185,519	5,559	27,666	6,918	28,886
	b1,149,733	b4,896,990	b493,370	b1,656,750	216,819	782,396	34,025	230,368	47,104	190,864

a Included in "Undistributed." b Revised.

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Lime sold in the United States in 1915 and 1916, by States and uses—Continued.

1915.

State or Territory.	Agriculture.		Dealers.		Other uses.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	379	$1,308	40,031	$169,600	1,303	$5,163	60,332	$250,227
Arizona	.....	.....	(a)	(a)	.....	.....	14,137	90,931
Arkansas	.....	.....	(a)	(a)	(a)	(a)	15,879	78,112
California	6,219	28,606	15,449	118,127	5,442	37,236	57,292	431,424
Colorado	(a)	(a)	(a)	(a)	(a)	(a)	4,647	29,131
Connecticut	1,066	4,667	.....	.....	.....	.....	76,022	368,343
Florida	.....	.....	.....	.....	.....	.....	b 9,243	b 47,920
Georgia	(a)	(a)	.....	.....	.....	.....	(a)	(a)
Hawaii	(a)	(a)	.....	.....	(a)	(a)	(a)	(a)
Idaho	.....	.....	(a)	(a)	.....	.....	3,357	19,247
Illinois	(a)	(a)	20,884	75,764	6,787	17,189	88,604	352,954
Indiana	6,207	20,065	28,347	108,961	14,090	47,864	99,916	374,221
Iowa	.....	.....	(a)	(a)	.....	.....	(a)	(a)
Kentucky	188	525	(a)	(a)	(a)	(a)	1,307	7,070
Maine	(a)	(a)	.....	.....	(a)	(a)	146,400	945,108
Maryland	b 113,176	356,768	450	1,200	.....	.....	b 130,597	409,588
Massachusetts	4,257	11,325	.....	.....	.....	.....	135,580	669,629
Michigan	(a)	(a)	8,989	39,506	11,075	43,706	81,359	349,979
Minnesota	.....	.....	.....	.....	.....	.....	20,359	96,190
Missouri	676	2,467	57,496	244,968	21,078	80,869	b 155,501	b 691,042
Montana	.....	.....	.....	.....	(a)	(a)	(a)	(a)
Nevada	.....	.....	.....	.....	(a)	(a)	(a)	(a)
New Jersey	8,909	27,610	299	1,561	.....	.....	10,273	35,393
New Mexico	.....	.....	.....	.....	(a)	(a)	1,720	11,963
New York	26,824	81,468	14,182	70,385	21,119	162,674	115,861	575,384
North Carolina	(a)	(a)	(a)	(a)	.....	.....	(a)	(a)
Ohio	54,118	203,221	192,044	767,527	55,898	187,841	507,993	1,954,810
Oklahoma	.....	.....	(a)	(a)	.....	.....	(a)	(a)
Oregon	.....	.....	(a)	(a)	.....	.....	4,188	30,411
Pennsylvania	345,960	995,703	55,839	215,053	44,453	135,769	901,549	2,947,058
Porto Rico	722	2,876	.....	.....	184	330	3,118	16,963
Rhode Island	(a)	(a)	(a)	(a)	.....	.....	(a)	(a)
South Carolina	(a)	(a)	.....	.....	.....	.....	(a)	(a)
South Dakota	.....	.....	.....	.....	(a)	(a)	5,025	34,728
Tennessee	3,520	9,150	4,836	14,730	7,804	23,438	82,765	256,069
Texas	(a)	(a)	23,629	126,572	1,980	10,216	39,468	211,516
Utah	.....	.....	(a)	(a)	(a)	(a)	11,460	67,273
Vermont	(a)	(a)	3,606	17,080	(a)	(a)	37,992	187,144
Virginia	45,149	170,557	(a)	(a)	(a)	(a)	267,278	840,969
Washington	(a)	(a)	(a)	(a)	(a)	(a)	27,240	171,023
West Virginia	32,558	111,921	10,037	23,955	78,932	317,065	250,000	896,520
Wisconsin	378	606	71,878	240,007	6,939	27,852	221,147	755,986
Wyoming	.....	.....	.....	.....	.....	.....	(a)	(a)
Undistributed	22,954	135,031	47,132	273,961	136,287	896,175	c 34,601	c 219,690
	b 673,260	2,163,874	595,128	2,508,907	413,371	1,993,887	b 3,622,810	b 14,424,036

a Included in "Undistributed."
b Revised.
c Includes Georgia, Hawaii, Iowa, Montana, Nevada, North Carolina, Oklahoma, Rhode Island, South Carolina, and Wyoming.

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Lime sold in the United States in 1915 and 1916, by States and uses—Continued.

1916.

State or Territory.	Building.		Fluxing.		Chemical works.		Paper mills.		Sugar factories.	
	Quantity (short tons).	Value.	Quantity (short tons.)	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	7,744	$33,069	.....	.....	703	$2,571	(a)	(a)	.....	.....
Arizona	(a)	(a)	.....	.....	.....	.....	.....	.....	.....	.....
Arkansas	17,637	94,875	.....	.....	(a)	(a)	(a)	(a)	.....	.....
California	15,529	119,198	(a)	(a)	4,351	28,308	.....	.....	9,225	$51,488
Colorado	299	1,790	(a)	(a)	(a)	(a)	.....	.....	(a)	(a)
Connecticut	84,707	587,528	.....	.....	(a)	(a)	.....	.....	.....	.....
Florida	4,898	30,216	.....	.....	.....	.....	.....	.....	.....	.....
Hawaii	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Idaho	3,217	21,686	.....	.....	.....	.....	(a)	(a)	.....	.....
Illinois	43,903	224,141	.....	.....	16,770	62,434	7,401	$30,459	(a)	(a)
Indiana	22,401	112,099	(a)	(a)	13,762	47,027	23,716	89,708	.....	.....
Iowa	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	.....	.....
Kansas	(a)	(a)	.....	.....	(a)	(a)	.....	.....	.....	.....
Kentucky	685	3,924	.....	.....	.....	.....	.....	.....	.....	.....
Maine	95,837	632,209	.....	.....	.....	.....	(a)	(a)	.....	.....
Maryland	6,357	24,681	.....	.....	41,398	140,744	.....	.....	.....	.....
Massachusetts	82,973	546,307	.....	.....	(a)	(a)	(a)	(a)	.....	.....
Michigan	2,649	13,824	(a)	(a)	59,510	261,441	4,739	20,522	.....	.....
Minnesota	18,150	90,750	.....	.....	.....	.....	.....	.....	.....	.....
Missouri	55,846	289,415	12,104	$49,546	16,050	82,874	(a)	(a)	(a)	(a)
Montana	(a)	(a)	(a)	(a)	.....	.....	.....	.....	.....	.....
Nevada	(a)	(a)	.....	.....	.....	.....	.....	.....	.....	.....
New Jersey	(a)	(a)	.....	.....	.....	.....	.....	.....	.....	.....
New Mexico	637	5,023	.....	.....	.....	.....	.....	.....	.....	.....
New York	9,660	52,405	(a)	(a)	3,162	19,129	35,449	176,180	(a)	(a)
North Carolina	.....	.....	.....	.....	.....	.....	(a)	(a)	.....	.....
Ohio	400,481	2,078,533	(a)	(a)	(a)	(a)	36,988	130,921	(a)	(a)
Oklahoma	.....	.....	(a)	(a)	.....	.....	.....	.....	.....	.....
Oregon	179	2,270	.....	.....	.....	.....	.....	.....	.....	.....
Pennsylvania	212,095	962,266	56,404	197,436	131,201	451,759	69,474	245,601	(a)	(a)
Porto Rico	743	4,104	.....	.....	.....	.....	.....	.....	1,702	16,845
Rhode Island	.....	.....	.....	.....	(a)	(a)	.....	.....	.....	.....
South Dakota	1,884	12,732	3,888	31,301	.....	.....	.....	.....	.....	.....
Tennessee	39,443	151,814	.....	.....	(a)	(a)	26,540	79,460	5,658	22,952
Texas	17,837	110,803	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Utah	6,041	46,144	(a)	(a)	.....	.....	.....	.....	(a)	(a)
Vermont	7,741	44,822	(a)	(a)	5,160	30,717	15,306	80,244	(a)	(a)
Virginia	73,592	330,715	(a)	(a)	189,335	695,027	(a)	(a)	(a)	(a)
Washington	5,494	35,931	.....	.....	(a)	(a)	(a)	(a)	(a)	(a)
West Virginia	44,604	156,600	(a)	(a)	97,342	338,923	.....	.....	.....	.....
Wisconsin	219,805	995,120	(a)	(a)	.....	.....	13,013	54,599	.....	.....
Wyoming	(a)	(a)	.....	.....	.....	.....	.....	.....	.....	.....
Undistributed	6,900	44,620	107,622	433,818	42,376	137,292	120,561	553,718	5,338	27,287
	1,509,968	7,859,614	180,018	712,101	621,120	2,298,246	353,187	1,461,412	21,923	118,572

a Included in "Undistributed."

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Lime sold in the United States in 1915 and 1916, by States and uses—Continued.

1916.

State or Territory.	Tanneries.		Agriculture.		Dealers.		Other uses.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	(a)	(a)	592	$2,246	50,007	$243,562	1,787	$7,149	67,524	$312,531
Arizona			(a)	(a)	(a)	(a)			15,173	94,540
Arkansas			(a)	(a)					19,199	102,683
California	1,289	$10,793	5,386	31,974	14,962	100,738	4,061	36,867	56,820	393,930
Colorado			(a)	(a)	(a)	(a)	(a)	(a)	5,479	36,473
Connecticut			(a)	(a)					85,063	589,257
Florida			(a)	(a)	(a)	(a)			8,666	49,536
Hawaii			(a)	(a)					(a)	(a)
Idaho							(a)	(a)	4,389	31,786
Illinois	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	80,012	369,038
Indiana	7,285	31,269	3,401	14,598	(a)	(a)	36,710	145,548	121,306	495,283
Iowa			(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Kansas									(a)	(a)
Kentucky			241	790	(a)	(a)	(a)	(a)	1,236	6,304
Maine			9,553	39,729	(a)	(a)			162,100	956,371
Maryland			109,468	407,930	(a)	(a)			157,673	574,998
Massachusetts			4,500	12,226	(a)	(a)	(a)	(a)	145,020	811,402
Michigan	1,300	6,250	(a)	(a)	16,786	76,117	(a)	(a)	86,447	385,341
Minnesota					(a)	(a)			20,150	103,000
Missouri	5,279	23,927	(a)	(a)	67,028	329,172	32,796	139,219	199,260	956,300
Montana					(a)	(a)			(a)	(a)
Nevada					(a)	(a)	(a)	(a)	(a)	(a)
New Jersey			6,517	22,202	(a)	(a)			7,110	26,084
New Mexico					(a)	(a)	(a)	(a)	1,582	11,670
New York	2,555	20,973	12,649	44,891	14,446	90,240	33,169	200,866	117,490	636,668
North Carolina	(a)	(a)	(a)	(a)	(a)	(a)			(a)	(a)
Ohio	(a)	(a)	49,527	224,120	37,251	125,999	33,829	113,882	570,972	2,702,953
Oklahoma					(a)	(a)			(a)	(a)
Oregon					(a)	(a)			4,225	35,289
Pennsylvania	17,757	70,955	318,722	1,036,222	9,570	33,341	156,110	856,409	972,343	3,857,553
Porto Rico	(a)	(a)	1,066	4,513			89	694	3,640	26,436
Rhode Island	(a)	(a)	(a)	(a)	(a)	(a)			(a)	(a)
South Dakota									5,772	44,033
Tennessee	(a)	(a)	2,080	4,410	10,412	43,173			109,533	378,017
Texas			(a)	(a)	23,303	131,074	3,102	16,073	54,049	307,759
Utah					(a)	(a)	(a)	(a)	12,472	77,133
Vermont	6,407	34,568	1,276	3,864	4,223	23,695	3,204	18,083	43,365	236,133
Virginia	1,470	5,180	38,751	147,843			14,598	66,028	326,812	1,279,658
Washington			(a)	(a)	13,566	84,149	(a)	(a)	26,895	166,653
West Virginia	(a)	(a)	41,507	160,959	(a)	(a)	(a)	(a)	277,721	1,008,021
Wisconsin	1,828	9,264	(a)	(a)	31,604	146,606			266,805	1,207,059
Wyoming									(a)	(a)
Undistributed	14,749	64,824	8,291	65,884	79,853	418,844	21,305	109,408	b 37,130	b 239,413
	59,919	278,003	613,527	2,224,401	373,011	1,846,730	340,760	1,710,226	4,073,433	18,509,305

a Included in "Undistributed."
b Includes Hawaii, Iowa, Kansas, Montana, Nevada, North Carolina, Oklahoma, Rhode Island, and Wyoming.

In 1916 only 6 States, compared with 11 in 1915, supplied lime for all the uses listed in the table; but 11 other States supplied lime for all but one or two uses, compared with 5 States in 1915. The 17 States in this group for 1916 ranked from 1 to 20 in total production, except Colorado, which ranked 31. All but Illinois, California, and Washington showed increase in quantity and value in 1916. The States that supplied lime for all uses in both years were Pennsylvania, Ohio, Virginia, Vermont, and Missouri, all but the last east of Mississippi River. New York, by supplying lime to sugar factories, joined this group in 1916, whereas of the States with all uses represented in 1915, Alabama, Indiana, and Michigan, failed to supply lime to sugar factories, California lime to paper mills, and Tennessee lime for fluxing and "other uses." The scope of the lime industry did not increase, therefore, in the country as a whole, although

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the quantity and value sold for each use, except sugar manufacturing and agriculture, increased considerably. The value of lime for agriculture also increased.

Building.—Lime reported as sold for building, after a general decrease for six years, represented an increased proportion of the total lime sold in 1916—37 per cent in quantity, compared with 32 per cent in 1915, and 43 per cent in value, compared with 34 per cent in 1915. The total quantity of lime actually used for building should doubtless include the greater part of that reported as sold to dealers.

Building lime in 1916 increased greatly both in quantity (31 per cent) and in value (60 per cent), reaching record figures. The average price per ton ($5.21), which had decreased 9 cents in 1914 and 10 cents in 1915, increased 95 cents in 1916. Lime was sold for building in 38 of the 42 producing States and Territories in 1916, and in 3 of the remaining 4 part of the lime sold to dealers was probably used for building. Ohio and Wisconsin in 1916 passed Pennsylvania, formerly the leading State. Ohio's quantity (400,481 tons) and value ($2,078,533) were both record figures. The increase in value was 190 per cent. No other State reached $1,000,000 in value of lime sold for building. Wisconsin was second with $995,120, a gain of 136 per cent, and, with sales to dealers included, the value exceeded $1,000,000. Pennsylvania's sales decreased, their value falling to $962,266—a decrease of 8 per cent in spite of increase in average price. Three other States, Maine, Connecticut, and Massachusetts, exceeded $500,000 in value of lime sold for building in 1916, whereas Pennsylvania and Ohio were the only States with such value in 1915. Missouri, with sales to dealers included, also exceeded $500,000 in 1916. Eight States had values between $100,000 and $500,000 in 1916, compared with 7 States in 1915, and 3 other States would be in this group in 1916, compared with 5 in 1915, were sales to dealers included. In short, 17 States showed combined values in excess of $100,000 in 1916, compared with 14 in 1915. In only 6 of these 17 States, Connecticut, Illinois, Maine, Massachusetts, Ohio, and Wisconsin, did the value of lime sold directly for building exceed 50 per cent of the total value; and in 6 others, Alabama, California, Missouri, Tennessee, Texas, and Washington, the combined value of lime sold for building and to dealers exceeded 50 per cent of the total. In all but 3 of these States, Maine, California, and Washington, the average price of all lime increased. This favorable influence in 1916 of building lime on the lime trade as a whole was in contrast to its prevailingly unfavorable influence in 1915.

Building activity and business in general in 1916 was especially brisk in manufacturing communities and regions tributary to them. The building lime industry in the New England States was generally prosperous, although retarded by strikes, shortage of labor and fuel, railroad embargoes, and at times by rains. Cost of production increased.

In the Middle Atlantic States the demand for building lime was better than in 1915, in spite of advance in price and bad conditions of labor and transportation. Among the factors influencing the demand were the increase in contracts in New York made before the law restricting heights of buildings became effective, and the increase in number and capacity of industrial plants, especially in eastern Penn-

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sylvania. Some producers, however, reported that production was curtailed and profits were reduced owing to scarcity of labor, and at least one plant, unable to get men, was obliged to remain idle for the last half of the year.

In the East Central and Southeastern States also there were increased demand and higher prices, but output was curtailed by increased cost of production and by shortage of labor, fuel, and cars. Inefficiency of labor was a contributing cause in some places, as was also true of the Middle West. Thus the cost of labor was reported by one company in Wisconsin to have more than doubled. Increase of production in Wisconsin and decrease in Illinois (already noted) were due to a considerable extent to the inactivity of certain companies in northern Illinois, whose markets were in consequence supplied by Wisconsin plants. Active companies in Illinois reported prices higher and conditions improved. The Chicago market during 1916, in contrast to 1915, was continuously active as a whole, in spite of strikes and high cost of materials.

In the west Central States increased prices and improved business conditions were reported, although Minnesota's sales decreased slightly in quantity. Some producers in Missouri, however, reported increased cost of production and poor shipping facilities. The St. Louis market was reported fair to good during the summer months.

Among the Southwestern States conditions were reported excellent in Texas, but no special reports on building lime were received from other States in this region or in the Rocky Mountain region.

Among the Pacific Coast States business conditions in California and Washington in 1916 were reported improved by some producers and poorer by others. Building during the year ending June 30, increased in the San Francisco district, but decreased in Los Angeles. During the second half of the year, however, the wet-mortar plant of the Blue Diamond Plaster Co., which began operations about May 1, 1916, was very active, especially in supplying mortar for churches, apartment houses, and dwellings. Wet-mortar plants in the Pacific coast region, according to W. C. Hay, inventor of the process, sold in 1916 approximately 115,000 tons of mortar, equivalent to 10,000 tons of lime and valued at about $350,000, compared with sales in 1915 of 90,000 tons of mortar, equivalent to 8,000 tons of lime and valued at about $270,000.

Chemical works.—Lime for chemical works, production of which passed all previous records in 1915, showed further gains in both quantity (26 per cent) and value (39 per cent) in 1916. The average price per ton ($3.70) increased 34 cents over that of 1915, and was greater by 25 cents than the previous record price of 1913 ($3.45). The continued increase in demand for lime for chemical works was to be expected from the great activity in the chemical industries.

Lime for chemical works represented 15 per cent of the total quantity and 12 per cent of the total value of lime sold in 1916, compared, respectively, with 14 per cent and 11 per cent in 1915. It was sold in 23 States in 1916, compared with 20 in 1915. Virginia was the ranking State in 1916, with 189,335 tons, valued at $695,027, passing far ahead of Pennsylvania, the former leading State in value, in spite of the latter's substantial gain. Other States whose sales were valued at more than $100,000 in 1916 were in order of

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rank, West Virginia, Michigan, and Maryland. New York, which belonged to this group in 1915, showed sales valued at only $19,129 in 1916. In all the five leading States except Pennsylvania the value of lime for chemical works exceeded the combined value of lime for building and dealers, and in Virginia and Michigan it exceeded 50 per cent of the total value of lime.

In addition to burned lime for chemical works, there were 2,836,557 tons of limestone, valued at $966,262, sold to alkali works in 1916. This limestone, sold and reported by the producers as stone, is included in the report on stone in 1916.

The Survey has recently received inquiries for lime and limestone of both high-calcium and high-magnesium varieties free from impurities, especially iron. Available analyses nearly all show only the combined percentage of alumina and iron oxides, and although in some this percentage is very small, the exact information desired is lacking. Some inquiries have called for stone containing not more than 0.05 per cent of iron. Even for uses where impure stone is satisfactory, if not required, the ratio as well as the quantity of the different impurities doubtless has a direct bearing on the quality of the burned material, and it is therefore urged that more complete analyses of limestone and lime be made.

Paper mills.—Lime for paper mills, after decreasing for two years, increased greatly in quantity and value in 1916. The sales were 61 per cent greater in quantity and 84 per cent greater in value than in 1915, and exceeded those of any preceding year, the value exceeding $1,000,000 for the first time since 1913. The average price per ton ($4.14) in 1916, which was lower in 1915 than in any of the five preceding years, nearly reached the record price ($4.18) of 1913. Limestone for paper mills increased from 52,262 tons, valued at $49,588, in 1915 to 80,338 tons, valued at $58,785, in 1916. A comparative discussion of the use of limestone or burnt lime for sulphite mills has been given in a recent paper by Jenssen.[1]

Lime for paper mills represented about 8 per cent of the total quantity and value of lime sold in 1916, compared with 6 per cent of the quantity and 5 per cent of the value in 1915. It was sold in 20 States in 1916 compared with 17 in 1915. Pennsylvania continued to be the leading State, with marked increase in quantity and value, the latter passing well above $200,000. New York and Ohio followed in order, each with values in excess of $100,000, and four other States had values in excess of $50,000, whereas in 1915 only five States exceeded $50,000 in value. The great gain in value among "other States" suggests that one or more of them may also have exceeded $50,000 in value in 1916. These increases are evidently due to greatly increased activity, especially in sulphite pulp mills, to meet the demand formerly supplied by imported wood pulp.

Sugar factories.—Lime for sugar factories was the only kind to show decrease in sales in 1916, declining 36 per cent in quantity and 49 per cent in value after corresponding rises of 7 per cent and 19 per cent in 1915. The average price per ton ($5.41), which had risen 89 cents in 1915, declined $1.36 in 1916.

[1] Jenssen, G. D., Limestone or burnt lime for sulphite mills: Paper, vol. 20, No. 14, p. 12, June 13, 1917.

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Lime for sugar factories, though sold in 14 States in 1916, two less than in 1915, represented only 0.5 per cent of the quantity and 0.6 per cent of the value. In only two States and Porto Rico were there three or more producers in 1916 compared with seven States in 1915. California, the leading State, showed only about one-third the value in 1916 that it did in 1915. Tennessee, the second State, also showed marked decrease. Porto Rico, however, more than doubled its value in 1916, its lime for sugar factories representing about three-fifths of the value of its total sales.

As both carbon dioxide and lime are used in the manufacture of sugar and as many manufacturers, therefore, prefer to buy or quarry limestone and burn their own lime, the demand for lime in this industry is more adequately shown in the following table:

Limestone and lime used by sugar factories, 1912–1916.

	1912	1913	1914	1915		1916	
				Quantity (short tons).	Value.	Quantity (short tons).	Value.
Limestone	$335,108	$387,724	$323,796	394,122	$381,038	369,028	$369,694
Lime	186,164	216,768	187,605	34,025	230,368	21,923	118,572
	521,272	604,492	511,401	.....	611,406	.....	488,266

These figures show a proportionately small decline in quantity and value of limestone in 1916, but the value of lime as well as the total value in 1916 was less than in any of the preceding years. Reference to the two previous reports on lime shows that the total value of limestone and lime for sugar factories has been declining as a whole since 1910, interrupted by rises in 1913 and 1915, the value for 1915 being the highest and that for 1916 being the lowest for any of these years.

Tanneries.—Sales of lime for tanneries, after declining in quantity and value in 1914 and 1915, made great gains in both respects in 1916, surpassing all previous years except 1909 when 72,899 tons, valued at $292,258, were reported. The quantity sold in 1916 (59,919 tons) was 27 per cent greater and the value ($278,003) 46 per cent greater than in 1915. The average price per ton, which was $4.62 in 1910 and had declined steadily during the five succeeding years, rose to $4.64 in 1916.

Lime for tanneries, in 1916 as in 1915, represented about 1.5 per cent of both the total quality and value of lime sold. It was sold in 17 States in 1916, compared with 15 in 1915. North Carolina, West Virginia, and Porto Rico joined the ranks of producers, and Texas dropped out. Pennsylvania displaced Vermont as the leading State, its value of production nearly doubling, while that of Vermont declined. Other States whose sales exceeded $10,000 in value were California, Indiana, Missouri, and New York. Michigan, Indiana, New York, and Virginia exceeded this value in 1915.

Agriculture.—The quantity of lime sold for soil amendment, in spite of optimistic comments in trade journals, continued to decrease

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from the record figure of 1914, falling off 2 per cent in 1915 and nearly 9 per cent more in 1916. The quantity in 1916, however, was greater than in any year prior to 1914. The value, on the other hand, has increased steadily—1 per cent in 1915 and nearly 3 per cent in 1916. The average price per ton ($3.63) increased 8 cents in 1915 and 42 cents in 1916.

Lime for agriculture in 1916 represented 15 per cent of the total quantity and 12 per cent of the total value marketed. It was sold in 31 States in 1916, compared with 29 in 1915. Arizona, Arkansas, Florida, and Iowa entered the list; Georgia and South Carolina dropped out. Pennsylvania, the leading State, showed decrease in quantity but increased in value to more than $1,000,000. Maryland the only other State with sales in excess of 100,000 tons, also showed a small decrease in quantity, but an increase in value. Of the other more important States, Ohio showed decrease in quantity and increase in value; Virginia decrease in both; and West Virginia increase in both. Several small and local producers went out of business.

In spite of the decrease in total quantity of agricultural lime sold, the increase in number of producing States points to a gradually broading recognition of the value of lime in agriculture. In addition to burned lime, a steadily increasing quantity of pulverized limestone has been sold for this purpose at an average price of little more than $1 a ton. The quantity of pulverized limestone sold in 1916 was 1,066,376 short tons, valued at $1,146,582. In the following table, showing the compartive sales of burned lime and of pulverized limestone for agriculture, the quantity of lime available in the limestone should be estimated at about 52 or 53 per cent.

Production of lime and pulverized limestone for agriculture, 1911–1916.

Year.	Lime.		Limestone.	
	Quantity (short tons)	Value.	Quantity (short tons)	Value.
1911	596,664	$1,714,386	174,290	$205,606
1912	604,607	1,852,530	200,000	311,702
1913	590,229	1,798,566	408,627	488,718
1914	684,348	2,139,444	615,197	668,951
1915	673,260	2,163,874	810,399	889,530
1916	613,527	2,224,401	1,066,376	1,146,582

Three interesting papers discussing lime on the farm by M. L. Fearnow have recently been published.[1] The first discusses the need of lime and how to detect it; the second, the forms of agricultural lime and their application; and the third, the origin of the soil and soil chemistry.

Dealers.—The large decrease in quantity (37 per cent) and value (26 per cent) of lime reported as sold to dealers in 1916 is not significant, except as an indication that the final use made of the lime has become better known than in previous years. A considerable quantity of lime formerly reported as sold to dealers was included in building lime in 1916.

[1] Nat. Lime Manufacturers' Assoc. Agr. Bulls. 1, 2, and 3, Riverton, Va.

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Lime was reported as sold to dealers in 33 States in 1916 compared with 29 States in 1915, but in 21 of the 33 States there were less than three producers so reporting and the total quantity reported by them was only 79,863 tons, or an average of 3,803 tons in each State. The total quantity of lime reported as sold to dealers was 9 per cent of the grand total. The smaller the percentage of lime that need be reported as sold to dealers, the greater the significance of the figures representing lime sold for specified uses. The greatest quantity reported from a single State in 1916 was 67,028 tons, valued at $329,172, from Missouri; other States whose values exceeded $100,000 were Alabama, Wisconsin, Texas, Ohio, and California—6 States, compared with 8 in 1915. The average price per ton ($4.95) increased 73 cents in 1916.

Fluxing and other uses.—According to the table the great increase in quantity and value of lime sold for miscellaneous or "other" uses in 1915 was followed by a marked decrease in 1916, but if lime for fluxing had been included in the figures for 1916, as they were in those of 1915, a considerable further increase would have been indicated. Lime for fluxing, heretofore the largest item in "other uses", has become so large in the last two years that its quantity and value are shown separately in this report. Lime for fluxing in 1916 was sold in 18 States, well distributed throughout the country, and represented 4 per cent of the total quantity and value; but in only 3 States were there more than three producers. Pennsylvania was easily the leading State, producing more than 31 per cent of the total quantity and nearly 28 per cent of the total value.

Lime for "other uses," exclusive of fluxing, was sold in 23 States in 1916 and represented 8 per cent of the total quantity and 9 per cent of the total value. Pennsylvania, the leading State, produced 46 per cent of the quantity and 50 per cent of the value. Other States with values in excess of $100,000 were New York, Indiana, Missouri, and Ohio.

HYDRATED LIME.

Hydrated lime in 1916, according to the accompanying table, showed an even more striking increase than total lime, the marketed production amounting to 717,382 tons, valued at $3,626,998—an increase of about 23 per cent in quantity and of nearly 48 per cent in value. Compared with these final figures for quantity, the preliminary statement of 710,000 tons, published in January, 1917, was an underestimate of 1 per cent. The percentage of increase in quantity was greater than in any of the three preceding years, but less than in 1912, when it was 37 per cent. The percentage of total lime represented by hydrated lime in 1916 was 18 per cent, or 2 per cent more than in 1915, which shows that the relative demand for hydrated lime continued to increase. The average price per ton, after declining as a whole from 1911 to 1915, exceeded $5 in 1916 for the first time.

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Hydrated lime manufactured and sold in the United States, 1906–1916.

Year.	Quantity (short tons).	Value.	Average price per ton.	Number of plants reporting operations.
1906	120,357	$479,079	$3.98	30
1907	140,135	657,636	4.69	33
1908	136,411	548,262	4.02	46
1909	204,611	904,900	4.43	50
1910	320,819	1,288,789	4.02	51
1911	304,593	1,372,057	4.50	60
1912	416,890	1,829,064	4.39	64
1913	493,269	2,205,657	4.47	80
1914	515,121	2,239,916	4.35	82
1915	581,114	2,457,602	4.23	84
1916	717,382	3,626,998	5.06	89

The increase in demand for hydrated lime is further indicated by the continued increase in number of active hydrating plants. There were 89 operated in 1916—an increase of 5, compared with increases of 2 in each of the two preceding years. The distribution of these plants is shown in the following table:

Lime-hydrating plants in operation in 1907–1916.

State or Territory.	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916
Alabama	1	1	3	2	2	2	2	3	3	3
Arizona	1	1	1	1	1					1
California	1	2	2	2	3	3	4	2	2	1
Colorado	1		1	1						
Connecticut			1			1		1	1	1
Florida		1		1			1		1	1
Georgia	1	1			1	1	1			
Hawaii				1					1	
Idaho			1	1	1	1			1	
Illinois	1	1	2	2	1	1	1	1	1	2
Indiana	2	2	2	2	2	2	2	3	3	3
Iowa			1				1	1		1
Kansas	1		1							
Kentucky							1	1		
Maine	1	1	1	1	1	1	1	1	1	1
Maryland		1	1	3	3	3	4	6	5	7
Massachusetts				1	2		1	1	1	1
Michigan	1	2	1	2	3	1	3	2	2	2
Missouri	2	2	3	3	3	4	4	6	5	6
New Jersey		1	1		2	1	1	1	1	1
New York	2	2	3		2	3	4	4	6	9
North Carolina					1					
Ohio	9	11	8	11	15	17	19	20	21	20
Pennsylvania	6	11	9	8	8	15	15	14	11	11
Rhode Island								1	1	1
South Dakota				1	1		1	1	1	1
Tennessee		1	1	1	1	1	2	2	2	3
Texas		1	3	3	3	3	3	3	3	3
Vermont										1
Virginia		1	2		1		2	1	2	2
Washington					1	1	2	2	2	2
West Virginia	1	1		2	1	2	3	3	4	3
Wisconsin	2	2	2	2	1	1	2	2	2	2
	33	46	50	51	60	64	80	82	84	89

New York (with an increase of 3 plants) and Maryland (with an increase of 2 plants) showed the largest gains, and Vermont (with 1 plant) joined the list of States producing hydrated lime. Ohio, the leading State in number of hydrating plants, after increasing its number steadily from 8 in 1909 to 21 in 1915, showed a decrease of 1 in 1916. Pennsylvania, the only other State with more

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than 10 plants, after decreasing in 1914 and 1915, showed no change in 1916.

The following table shows for the first time the production of hydrated lime by States:

Hydrated lime sold in the United States in 1916.

State.	Quantity (short tons).	Value.	State.	Quantity (short tons).	Value.
Alabama	6,780	$36,864	Ohio	351,792	$1,906,974
Arizona	(a)	(a)	Pennsylvania	126,890	585,847
California	(a)	(a)	Rhode Island	(a)	(a)
Connecticut	(a)	(a)	South Dakota	(a)	(a)
Florida	(a)	(a)	Tennessee	14,684	72,777
Illinois	(a)	(a)	Texas	14,575	86,852
Indiana	22,615	111,278	Vermont	(a)	(a)
Iowa	(a)	(a)	Virginia	(a)	(a)
Maine	(a)	(a)	Washington	(a)	(a)
Maryland	31,913	158,311	West Virginia	48,309	209,155
Massachusetts	(a)	(a)	Wisconsin	(a)	(a)
Michigan	(a)	(a)	Undistributed	64,318	378,089
Missouri	24,647	128,903			
New Jersey	(a)	(a)		717,382	3,626,998
New York	10,909	51,948			

a Included in "Undistributed."

Comparison of these figures with unpublished reports for 1915 shows that all States whose marketed production exceeded 5,000 tons increased their sales in 1916. This statement includes some of the States whose total quantity of lime decreased in 1916. Ohio, the leading State, showed approximately three times the quantity and value of Pennsylvania, the only other State whose quantity exceeded 100,000 tons. West Virginia, with only three active plants, ranked third. New York, which ranked third in number of plants, was ninth in production.

The greater part of the hydrated lime marketed, as shown in the table below, is used for building and represents about 29 per cent of the total quantity of lime used for building. This percentage does not include lime that was purchased as quicklime and hydrated before being sold to builders. Were such lime included the 10,000 tons of lime used by the wet mortar plants in California (see page 445) should be calculated as hydrated lime, as this lime is hydrated and aged before being mixed with the other ingredients of the mortar. Even with such lime added, however, and with the steady increase in production of hydrated lime during the last 11 years, the percentage shown above indicates that there is still ample opportunity for further rapid increase in production of hydrated lime for building operations.

Hydrated lime sold in the United States in 1916, by uses.

Use.	Quantity (short tons).	Value.
Building	431,582	$2,276,365
Agriculture	184,944	869,654
Other	100,856	480,979
	717,382	3,626,998

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The quantity sold for building includes that used in concrete and cement mortar to increase its plasticity and to render it less permeable. Interesting statements by engineers showing how these properties in concrete are affected by addition of hydrated lime are contained in recent bulletins of the Hydrated Lime Bureau.[1] Other papers bearing on this subject are as follows:

Wiedmann, H. E., The use of hydrated lime in concrete: St. Louis Eng. Club Jour., vol. 1, pp. 161–173, 1916.

Hough, N. G., Mixing hydrated lime and cement at the mill: Concrete, July 11, 1917, p. 25. Answers inquiry why, if addition of hydrated lime is beneficial, cement manufacturers do not add it at their plants.

A modern hydrated lime plant: Cement and Engineering News, October, 1916, pp. 218–219.

Fuller, M. O., Tensile strength of Portland cement mortars containing lime: Concrete, September, 1916, pp. 89-91. Results of experiments show that an addition of hydrated lime up to 10 per cent of the cement not only increases very considerably the plasticity of the mortar, but also increases the tensile strength.

Letters on hydrated lime which won prizes: Engineering Record, December 23, 1916, pp. 764–765. Experiences of three engineers citing advantages of material in construction of bridges and of a water-filtration plant.

Lathem, E. H., Solving the plasticity problem in lime manufacture: Concrete-Cement Age, January, 1915, Cement mill section, pp. 9–11. States belief that degree of plasticity depends on completeness of hydration and the opportunity for each particle, when brought into contact with water, to become separated from other particles by a film of water. Discusses means of increasing thoroughness of hydration.

Lazell, E. W., Advantages in use of commercially hydrated lime over ordinary slaked lime: Concrete-Cement Age, March, 1915, pp. 139–140. Cites advantages from standpoints of manufacturer, dealer, and consumer.

Meade, R. K., Modern methods and equipment in the manufacture of hydrated lime: Concrete-Cement Age, August, 1915, Cement mill section, pp. 13–17.

Conwell, E. L., Lazell, E. W., and Hurd, H. B. H., The use of lime hydrates in factory-made concrete units: Concrete-Cement Age, November, 1915, pp. 186–187. Cite differences in slaking properties of high-calcium and high-magnesium hydrates, but state that effects of adding either to concrete are the same, and that efflorescence on concrete products is not increased by addition of the correct amount of hydrated lime.

Hough, N. G., Conwell, E. L., and Hurd, H. B. H, The use of hydrated lime in dry-tamp mixtures of concrete: Concrete-Cement Age, May, 1916, pp. 228–229.

Hough, N. G., Hydrated lime and its advantages in concrete: Cement Era, August, 1916, pp. 46–47. Brief discussion of influence of hydrated lime in increasing plasticity, homogeneity, and impermeability of concrete.

The effect of hydrated lime on the compressive strength of concrete has also been under investigation. Results of preliminary tests by the Bureau of Standards[1] show that in test pieces of hand-mixed, tamped concrete, made of rather dry consistency and stored in a damp closet, substitution of hydrated lime for cement causes in general a diminution of compressive strength. Diminution in strength caused by hydrate when 1:1½:3 concrete is stored in air is not nearly so great as when it is stored in the damp closet. The results vary, however, with different proportions of aggregate, and indicate that the sizing of the ingredients may be one of the important factors in determining the value of hydrated lime in concrete. With specimens up to six months in age there is no appreciable difference in behavior between high-calcium and high-magnesium hydrate. The

[1] Dependable concrete (Bull. A–2, 14 pp.); Modern methods in concrete construction (Bull. A–5, 14 pp.); Nat. Lime Mfrs. Assoc. Hydrated Lime Bureau, Pittsburgh, Pa.

[1] Emley, W. E., and Kaczorowski, S. K., The effect of hydrated lime on the compressive strength of concrete: Nat. Lime Mfrs. Assoc. Bull 2 (advance of minutes, June, 1917), 4 pp.

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author's closing statement is that there is no evidence at present to show the effect of hydrate on concrete which is either machine-mixed, poured, or aged in air, and that interpretation of the present figures to obtain such information is not justifiable.

Another interesting series of experiments was conducted by Prof. J. S. Macgregor for the Hydrated Lime Bureau.[1] His results show that mortars containing increasing quantities of hydrated lime, substituted volumetrically for cement, normally show gradual reductions in compressive strength when tested as mortar specimens not in contact with bricks; but that when used as mortar in contact with moisture-absorbing bricks they show substantial increases in strength in all volumetric replacements up to 50 per cent.

The standard specifications for hydrated lime, in use since 1915, have found wide application, but, as was expected by the committee that adopted them, have not proved entirely satisfactory. In fact, there are very few hydrates now on the market that will pass the specifications, and these do not include the dolomitic hydrates, whose commercial value is so well known. Result of tests by Emley and Stearns, of the Bureau of Standards, show that only 8 of 34 samples from manufactures can pass the present specifications. They have, on the basis of their tests, proposed a revision of the specifications, confining their attention to hydrate for building.[2]

CONSUMPTION OF LIME.

CONSUMPTION BY STATES.

The following is a first attempt to show the consumption of domestic lime and its relation to production in different States. Although the inquiries for this information called for additional time and labor on the part of the producers, the great majority were very ready to cooperate and, as their production represented over 99 per cent of the total, any errors in estimating for those who did not furnish data are negligible. The results of the canvass are given in the table on page 454. An obvious omission from this table is the small quantity reported by some producers as exported—12,337 tons. As producers reported only the States to which they shipped, and not necessarily the ultimate destination of the lime, it is evident that the difference is included in the consumption of certain seacoast States. It is also possible that some lime shipped to dealers near the boundary of one State may have been reshipped by them into another State. Another small omission is the imported lime (7,959 tons), which doubtless would modify somewhat the figures of consumption for California and Washington, if not of other States easily reached from Canadian centers of production.

[1] The ideal mortar for brick masonry: Nat. Lime Mfrs. Assoc. Hydrated Lime Bureau Bull. J, 32 pp., June, 1916.

[2] Emley, W. E., and Stearns, O. F., Revision of the standard specifications for hydrated lime: Nat. Lime Mfrs. Assoc. Bull. 8 (advance of minutes, June, 1917), 17 pp.

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Lime consumed in the United States in 1916.

State or Territory.	Lime.				Population.	Consumption of lime per capita (short tons).
	Produced (short tons).	Consumed (short tons).	Shipped out of State (short tons).	Shipped into State (short tons).		
Alabama	67,524	22,977	48,452	3,905	2,332,008	0.01
Arizona	15,173	4,938	13,528	3,293	255,544	.02
Arkansas	19,199	10,241	11,401	2,443	1,739,723	.005
California	56,820	71,691	2,568	17,439	2,938,654	.02
Colorado	5,479	15,288	.....	9,809	962,060	.015
Connecticut	85,063	52,564	49,252	16,753	1,244,479	.04
Delaware	.....	32,531	.....	32,531	213,380	.15
District of Columbia	.....	18,468	.....	18,468	363,980	.05
Florida	8,666	13,972	144	5,450	893,493	.015
Georgia	.....	33,291	.....	33,291	2,856,065	.01
Hawaii	(a)	3,638	.....	(a)	215,741	.016
Idaho	4,389	3,544	4,040	3,195	428,566	.01
Illinois	80,012	347,367	21,080	288,435	6,152,257	.056
Indiana	121,300	91,830	69,834	43,358	2,816,317	.03
Iowa	(a)	31,749	(a)	23,199	2,220,321	.01
Kansas	(a)	24,438	.....	(a)	1,829,545	.01
Kentucky	1,236	21,267	.....	20,031	2,379,639	.01
Louisiana	.....	29,386	.....	29,386	1,829,130	.016
Maine	162,100	91,924	99,290	32,114	772,489	.12
Maryland	157,673	187,649	53,784	83,760	1,362,907	.14
Massachusetts	145,020	152,545	107,770	115,295	3,719,156	.04
Michigan	86,447	189,930	11,274	114,757	3,054,854	.06
Minnesota	20,150	31,065	7,850	18,765	2,279,003	.01
Mississippi	.....	12,441	.....	12,441	1,951,674	.006
Missouri	199,260	72,151	140,767	13,658	3,410,902	.02
Montana	(a)	8,805	(a)	2,143	459,494	.02
Nebraska	.....	15,946	.....	15,946	1,271,375	.01
Nevada	(a)	7,555	.....	(a)	106,734	.07
New Hampshire	.....	33,802	.....	33,802	442,506	.076
New Jersey	7,110	150,628	349	143,867	2,948,017	.05
New Mexico	1,582	2,277	363	1,058	410,283	.005
New York	117,490	352,695	56,313	291,518	10,273,375	.03
North Carolina	(a)	77,741	(a)	72,189	2,402,738	.03
North Dakota	.....	3,212	.....	3,212	739,001	.004
Ohio	570,972	261,982	399,828	90,838	5,150,356	.05
Oklahoma	(a)	18,374	(a)	16,845	2,202,081	.01
Oregon	4,225	7,885	2,912	6,572	835,741	.01
Pennsylvania	972,343	1,009,587	229,785	267,029	8,522,017	.12
Porto Rico	3,640	3,640	.....	.....	1,216,063	.003
Rhode Island	(a)	11,208	(a)	8,856	614,315	.02
South Carolina	.....	12,708	.....	12,708	1,625,475	.01
South Dakota	5,772	8,749	903	3,880	698,509	.01
Tennessee	109,533	31,803	79,422	1,692	2,288,004	.01
Texas	54,049	42,947	12,930	1,828	4,429,566	.01
Utah	12,472	12,429	103	60	434,063	.03
Vermont	43,365	5,334	39,579	1,548	363,099	.01
Virginia	326,812	236,918	124,945	35,051	2,192,019	.11
Washington	26,895	15,506	14,212	2,823	1,534,221	.01
West Virginia	277,721	46,718	263,192	32,189	1,386,038	.03
Wisconsin	266,805	108,054	193,330	34,579	2,500,150	.04
Wyoming	(a)	1,708	.....	(a)	179,559	.01
Undistributed	37,130	.....	4,013	28,867	.....	.04
	b 4,073,433	4,061,096	b 2,063,213	2,050,876	103,449,136	

a Included in "Undistributed."
b Includes 12,337 short tons shipped out of the country.

A striking feature of this table is that in only 17 States did production exceed consumption. Another is that Pennsylvania, whose production exceeded that of any other State by 376,688 short tons, consumed more than it produced, its consumption exceeding 1,000,000 tons. Other States with production in excess of 100,000 tons that consumed more than they produced were Maryland, Massachusetts, and New York. Of the leading States whose production exceeded consumption, Ohio, West Virginia, Wisconsin, Missouri, and Tennessee, produced more than twice their consumption. Considerable quantities, however, were shipped into these States as shown in the fifth column of the table. The following 10 States consumed more

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than 100,000 tons; Pennsylvania, New York, Illinois, Ohio, Virginia, Michigan, Maryland, Massachusetts, New Jersey, and Wisconsin. In 7 of these States consumption exceeded production.

The ratio of production to consumption is governed not only by the presence of suitable deposits of limestone and of large markets within a State but by the proximity of these markets to producing centers of adjacent States and to convenient lines of transportation. Thus the city of greater New York, situated in the southeast corner of the State at tidewater, can be more cheaply supplied from Maine, western Connecticut and Massachusetts, and eastern Pennsylvania than from the deposits in the central part of its own State. The large cities along the New York Central Railroad, from Albany to Buffalo and in the northwestern part of the State, are most easily reached from deposits within the State; but the east-central part of the State is also readily supplied from western Massachusetts and Vermont and the west-central part may be reached by Lake shipping from Ohio. The 291,518 tons shipped into New York came from 15 States, but shipments from 6 of these States were small. In addition to these factors, certain special grades of lime may be in demand even though their transportation to market causes high freight costs. States to which lime was shipped from New York include those mentioned above in this paragraph and several others—17 in all. Some of these were a considerable distance from New York, and, although some could be reached by water, others could be reached only by rail. Most of the shipments, especially those to the more remote States, were in small lots and doubtless included lime of special grade, but shipments to adjacent States ranged as high as 17,000 tons.

By far the greater part of Pennsylvania's production was consumed within the State, presumably in the eastern part, where most of the important producing centers as well as the bulk of the population are located. Lime for agriculture, which exceeded any other kind in quantity, was produced and consumed throughout the greater part of the State. The 267,029 tons shipped into the State came from 13 States, but from 8 of these States shipments amounted to only about 800 tons. The largest shipments into the State were probably to the western part, which is more favorably connected by rail with important producing centers of neighboring States than with its own. Shipments from Pennsylvania were made to 23 States, of which Colorado was the most distant. Shipments exceeding 1,000 tons were made to 12 States. By far the greater shipments went to New Jersey, a very small producer, and to New York. A considerable quantity also went to Delaware, in which there was no production. Other considerable shipments went to States that ship[p] important quantities into Pennsylvania.

Shipments into Maryland came from 4 neighboring State[s] eral of whose producing centers were favorably situated wit[h] to the Baltimore market. These shipments were in part sated by shipments from Maryland into the same States. S[hi] from Maryland went to 9 States, most of them near by and 6 as receiving considerable quantities. in

New Jersey which has limestone deposits only in its northw[est] part and has an annual production of less than 10,000 tons, r[a]nk ninth in consumption. Nearly all of its production was used fo[r]

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culture within its own boundaries, small quantities going to New York and Pennsylvania. Most of the large cities of the State are easily reached from the large producing centers of eastern Pennsylvania and much more lime was shipped into New Jersey from this State than from any other. Total shipments into New Jersey came from 11 States.

Massachusetts, like New Jersey, has its important limestone deposits confined to one part of its area, the western, near the markets of New York and western New England, whereas most of its large cities are in the eastern half of the State and are readily reached from other sources by water or rail. These factors are reflected in the fourth and fifth columns of the table, which show that the bulk of the lime produced was shipped out of the State, and the bulk of that consumed was shipped into it. They are a striking illustration of the difference between commercial and political districts. Lime shipped into Massachusetts came from 12 States, 5 of which shipped considerable quantities. Small quantities were shipped from 3 States bordering Mississippi River. Shipments from Massachusetts were made to 10 States, 5 of which received considerable quantities.

Illinois consumed only a little less lime than New York, and more than four times its own production. This was evidently due largely to the situation of the Chicago market with respect to transportation facilities. Some plants in the northern part of the State are little nearer to Chicago than those in southeastern Wisconsin and northwestern Indiana; furthermore water transportation is favorable to more distant producing centers on or near the Great Lakes. Another factor, shown by many chemical analyses, is that the limestone burned in northern Illinois and southeastern Wisconsin are prevailingly of the high-magnesium variety, and industries requiring high-calcium lime look to more distant sources of supply. In addition to these factors the present status of the lime industry supplying the Chicago market is the result of severe competition both with other materials and among lime producers, and decrease both in number of active plants and in quantity produced during the last few years indicates that this competition has not been favorable to Illinois. The 288,435 tons shipped into Illinois came from 6 States, large quantities coming from 4 States. The 21,080 tons shipped out of Illinois went to 21 States distributed between the Atlantic coast and the Rocky Mountains. Shipments to only 5 neighboring States exceeded 1,000 tons each.

Michigan, whose production was mostly used within its borders, but whose consumption greatly exceeded production, was governed the same natural conditions that affect Illinois. Detroit and of its other large cities are easily reached from other sources of than those within the State, and Detroit, a Lake port, is espe- vored. The 114,757 tons shipped into Michigan came from p es, two of which made large shipments and four of which co ss than 1 ton each. Shipments from Michigan went to 00 hboring States on the Great Lakes.

c 10 leading States in consumption of lime, whose production consumption, Ohio was by far the most noteworthy. Ohio, ter part of whose lime was used for building, consumed only d of its own production and received shipments from nine hree of which shipped less than 7,000 tons each. Several pro-

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ducing centers in these States, though rather distant, are conveniently connected with important Ohio markets, and some may produce special grades of lime that have a more than ordinary range of distribution. Lime shipped from Ohio went to 37 States, including Maine on the east, Florida on the south, and California on the west. Twenty-one of these States received more than 1,000 tons each, and of the nine States that shipped lime into Ohio, eight received much more than they shipped. Shipments to the more distant States were, of course, small and probably consisted of lime of special quality.

Wisconsin, which shipped out nearly twice as much lime as it consumed, received shipments from nine States, four of which shipped less than 1,000 tons each. The same conditions suggested as affecting shipments into Ohio may be applicable to Wisconsin. Lime shipped from Wisconsin went to 14 States, of which the farthest west was Montana and the farthest east was Massachusetts. Five neighboring States received more than 1,000 tons each.

Virginia, which ranked fifth in consumption, was the only other leading State whose production exceeded consumption. It received shipments from five neighboring States, no one of which shipped less than 1,500 tons. Lime shipped out of Virginia went to 11 States east of Mississippi River, only two of which received less than 1,000 tons each.

Of the two leading States on the Pacific coast California produced less and Washington more domestic lime than it consumed. Lime was shipped into California principally from Arizona and Washington, and a small quantity came from Ohio. In addition a considerable quantity was doubtless imported from British Columbia, as it has been reported that the lime industry on Texada Island, British Columbia, has reached such proportions that the Pacific Lime Co., of Vancouver, employs a four-masted schooner to carry its product to San Francisco.[1] Most of the lime shipped out of California went to Nevada, and small quantities went to Arizona and Oregon—all States with low consumption. Shipments into Washington were made from Idaho and Oregon, presumably to markets more easily reached from these States than from the principal producing center of Washington on Puget Sound. Lime shipped from Washington went to six States, as far east as Mississippi River, and to Hawaii. California and Oregon received the largest quantities.

The situation of most of the large markets of the Pacific Coast States on tidewater naturally favors the principal producing center of Washington and also Texada Island, British Columbia, but only one of several centers in California. Here again the boundaries of commercial districts differ markedly from those of States. Ruinous competition, however, as previously reported by producers of the region, and cheaper labor conditions in British Columbia, have modified natural conditions to a considerable extent.

CONSUMPTION PER CAPITA.

The apparent consumption of lime per capita in different States, as given in the table, shows considerable variation—from 0.15 ton in Delaware to 0.004 ton in North Dakota and 0.003 ton in Porto Rico. Several factors govern the consumption, especially the kinds of

[1] Met. and Chem. Engineering, June 15, 1917.

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industries in different States, more competition with other materials in some States than in others, and the probability that lime reported by dealers as shipped to one State may ultimately have reached a different State. Furthermore as this first attempt to show per capita consumption was for a year characterized by unusual demand for lime in manufacturing centers, the difference in consumption between manufacturing States and agricultural States was probably greater than normal.

Only 12 States in 1916 had a per capita consumption above the average for the country (0.04 ton), and these, with the exception of Nevada, lie east of Mississippi River and from Virginia northward. States with per capita consumption of 0.03 ton, with the exception of Utah, also occupy the same general territory. By far the greatest per capita consumption was in the continuous area covered by Pennsylvania, Maryland, Delaware, and Virginia. Maine was the only other State with a per capita consumption of more than 0.10 ton. That Delaware, the smallest State in area, next to smallest in population, and not a producer of lime, had the largest apparent per capita consumption may have been due largely to activities in Wilmington, which includes about half its population, and perhaps also to some reshipment of lime in vessels from Wilmington. In Maryland and Pennsylvania more agricultural lime was consumed than any other kind, and chemical lime was also an important product. In Virginia chemical lime was the most important product, with agricultural lime representing a considerable portion of the total. In Pennsylvania and Virginia building lime represented about one-fourth of the total, and in Maryland was evidently much less. Within this area, the District of Columbia, the bulk of whose lime was doubtless used in public and commercial buildings and city dwellings, has a per capita consumption of 0.05 ton.

In Massachusetts and Connecticut, whose per capita consumption equaled the average for the country, about one-half the population is in cities of 40,000 or more inhabitants, in most of which manufacturing industries are important; but in Rhode Island, about three-fifths of whose population is in manufacturing cities, the per capita consumption was only 0.02. In these three States the greater part of the lime produced, and probably of that consumed, was for building, and only in Massachusetts were any considerable quantities sold for other uses listed in this report. This difference in per capita consumption may deserve some attention from lime salesmen.

In Maine and New Hampshire, where the larger cities comprise only a minor fraction of the population, the principal uses of lime were probably for building and paper manufacturing, and as the population of both States is small, a few active manufacturing plants may raise the per capita consumption considerably. In Vermont, where the population is smaller and less concentrated, the per capita consumption is only 0.01 ton.

In most if not all of the other States east of Mississippi River that consumed 0.03 ton or more per capita, the greater part of the lime was used for building. Chemical industries were also important, as was paper manufacturing.

That Missouri, with so large a production, should have a per capita consumption of only 0.02 ton, is somewhat surprising. Its total

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population, however, is less than that of Massachusetts, and is only about one-third concentrated in the larger cities, whereas its much greater area implies that the remaining two-thirds is more scattered and is in correspondingly less need of buildings that require considerable quantities of lime. About three-fifths of the lime produced in Missouri was for building.

The only other State of large population with a per capita consumption of 0.02 ton was California, about one-half of whose population is concentrated within large cities. Building lime was the principal part of the State's production, most of which was consumed within its limits, although chemical works, sugar factories, and agriculture consumed considerable minor quantities. These factors, compared with those in other States, suggest that per capita consumption of lime in California was abnormally low. In Washington, where more than one-third of the population is concentrated in large cities and building lime constituted two-thirds of the output, the per capital consumption was only 0.01 ton. The same factors hold true for Oregon, and it appears, therefore, that, so far as natural conditions are concerned, the per capita consumption of lime in the Pacific Coast States should be greater than it is.

In the other States of the country, all of which consumed 0.016 ton or less per capita, the population is relatively scattered, and in several States there is a greater proportion of small houses and cabins that call for much less lime than the average dwelling in the Eastern States. In two, Colorado and South Dakota, the greater part of the lime was used by smelters, but in the others it doubtless went into building.

IMPORTS.

Imports of lime for consumption in the United States in 1916 were reported by the Bureau of Foreign and Domestic Commerce as 7,959 short tons, valued at $71,663 at port of entry, as compared with 1,956 short tons, valued at $22,489 in 1915, an increase in quantity of 6,003 tons and in value of $49,174. This increase followed a decrease that had been steady for some years. The quantity imported in 1916 was about 0.2 per cent of the domestic marketed production.

The following table of general imports, which in 1916 were the same as imports for consumption, was compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce:

Lime imported into the United States in 1915 and 1916.

	1915		1916	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Germany	302	$5,547	.....	.....
England	[a] 1	134	15	$64
Canada	1,727	15,290	7,775	70,390
Mexico	114	723	168	1,187
Hongkong	[b]	2	.....	.....
Japan	[c]	11	1	22
	2,144	21,707	7,959	71,663

[a] 2,300 pounds. [b] 200 pounds. [c] 1,000 pounds.

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EXPORTS.

Exports of lime, as shown in the accompanying table, increased in quantity and value in 1916 after decreasing in the two preceding years. They represented 0.6 per cent of the quantity marketed and 0.7 per cent of the value, compared respectively with 0.4 per cent and 0.7 per cent in 1915.

Lime exported from the United States, 1913–1916.

Year.	Quantity (short tons).	Value.	Average price per ton.
1913	29,475	$212,345	$7.20
1914	24,141	170,744	7.07
1915	16,223	106,312	6.55
1916	23,973	132,769	5.54

The figures in the following table were furnished by the Bureau of Foreign and Domestic Commerce, United States Department of Commerce.

Lime exported from the United States, 1915–1916.

Country.	1915		1916	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Canada	14,846	$82,258	22,280	$107,820
Newfoundland and Labrador	1	17	(a)	10
Mexico	520	6,103	368	5,722
Central America:				
British Honduras	5	49	6	61
Costa Rica			13	164
Guatemala	4	40	4	39
Honduras	109	996	167	1,454
Nicaragua	86	989	258	3,226
Panama	138	2,225	149	3,208
Salvador			(a)	9
West Indies:				
Cuba	15	255	161	1,553
Haiti	1	20	1	18
Dominican Republic	149	4,483	247	4,947
Danish West Indies	57	1,276	66	985
French West Indies	2	72		
Barbados	21	446	5	100
Bermuda	(a)	4	(a)	6
Trinidad and Tobago			(a)	6
Other British West Indies	13	259	(a)	5
South America:				
Argentina	21	467	(a)	6
Brazil			7	112
Chile			5	93
Colombia	2	39		
British Guiana	(a)	4		
Dutch Guiana	9	180		
French Guiana			1	20
Peru	46	1,039	163	2,033
Uruguay	6	124		
Venezuela			9	222
England	141	4,351		
Scotland			34	340
Australia	(a)	12	24	480
New Zealand	27	555		
British Oceania			5	130
French Oceania	4	49		
	16,223	106,312	23,973	132,769

a Less than 1 ton.

Canada, as usual, received almost the entire exports and Mexico and Central America received about five-eighths of the remainder.

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All these countries showed increase in 1916. The Dominican Republic, Cuba, and Peru, the largest consumers in the West Indies and South America also showed increase; but England, the only other country to import more than 100 tons in 1915, imported none in 1916.

FUELS.

Statistics, shown in the accompanying table, of the kinds of fuel used in burning lime indicate that the number of kilns remained about the same, increase in several States offsetting a large decrease in Pennsylvania. The number of kilns using coal and wood also remained about the same. The number using wood alone, after decreasing 23 in 1915 increased 28 in 1916, small gains in several States exceeding losses in others. Increase of 5 in 1916 in the number using oil partly compensated for a decrease of 11 in 1915, the change taking place chiefly in California. The number using coal and coke more than doubled in Pennsylvania and also increased in Maryland, but no kilns were operated by this fuel in Virginia. The number using coke alone in Maryland and Pennsylvania decreased. The only other fuels to decrease in use were natural gas, used principally in Ohio, and shavings, used only in Illinois.

Number of lime kilns using various kinds of fuel in 1915 and 1916.

1915.

State or Territory.	Coal.	Wood.	Oil.	Natural gas.	Producer gas.	Coke.	Shavings.	Coal and wood.	Coal and coke.	Total.
Alabama	5	8	.....	.....	8	1	.....	20	.....	42
Arizona	.....	6	.....	.....	.....	.....	.....	.....	.....	6
Arkansas	.....	12	.....	.....	.....	.....	.....	.....	.....	12
California	.....	11	25	.....	.....	7	.....	.....	.....	43
Colorado	5	.....	.....	.....	.....	.....	.....	.....	.....	5
Connecticut	5	20	.....	.....	2	.....	.....	.....	.....	27
Florida	.....	19	.....	.....	.....	.....	.....	.....	.....	19
Georgia	.....	1	.....	.....	.....	.....	.....	.....	.....	1
Hawaii	.....	2	.....	.....	.....	.....	.....	.....	.....	2
Idaho	.....	5	.....	.....	.....	1	.....	.....	.....	6
Illinois	4	4	.....	.....	1	.....	25	.....	.....	34
Indiana	45	1	.....	.....	2	.....	.....	.....	.....	48
Iowa	.....	5	.....	.....	.....	.....	.....	.....	.....	5
Kentucky	2	3	.....	.....	.....	.....	.....	.....	.....	5
Maine	38	11	.....	.....	.....	.....	.....	.....	.....	49
Maryland	59	.....	.....	.....	.....	51	.....	6	14	130
Massachusetts	10	8	.....	.....	7	.....	.....	20	.....	45
Michigan	.....	26	.....	.....	1	.....	.....	4	.....	31
Minnesota	6	7	.....	.....	.....	.....	.....	.....	.....	13
Missouri	23	30	.....	.....	2	.....	.....	18	.....	73
Montana	.....	7	.....	.....	.....	.....	.....	.....	.....	7
Nevada	.....	.....	2	.....	.....	.....	.....	.....	.....	2
New Jersey	18	1	.....	.....	.....	.....	.....	.....	.....	19
New Mexico	2	1	.....	.....	.....	.....	.....	.....	.....	3
New York	35	15	.....	.....	.....	.....	.....	4	.....	54
North Carolina	1	.....	.....	.....	.....	.....	.....	4	.....	5
Ohio	208	8	.....	38	45	.....	.....	5	.....	304
Oklahoma	.....	2	.....	.....	.....	.....	.....	.....	.....	2
Oregon	.....	2	.....	.....	.....	.....	.....	.....	.....	2
Pennsylvania	684	16	.....	3	4	124	.....	52	31	914
Rhode Island	1	.....	.....	.....	.....	.....	.....	.....	.....	1
South Carolina	.....	1	.....	.....	.....	.....	.....	.....	.....	1
South Dakota	2	4	2	.....	.....	.....	.....	.....	.....	8
Tennessee	29	7	.....	.....	.....	.....	.....	6	1	43
Texas	3	4	7	2	.....	5	.....	4	.....	25
Utah	7	3	.....	.....	.....	7	.....	.....	.....	17
Vermont	.....	3	.....	.....	4	.....	.....	9	.....	16
Virginia	36	18	.....	.....	3	33	.....	18	11	119
Washington	.....	12	.....	.....	.....	.....	.....	.....	.....	12
West Virginia	25	1	.....	.....	3	40	.....	4	1	74
Wisconsin	.....	113	.....	.....	2	.....	.....	.....	.....	115
Wyoming	.....	.....	.....	.....	.....	.....	.....	1	.....	1
	1,253	397	36	43	84	269	25	175	58	2,340

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Number of lime kilns using various kinds of fuel in 1915 and 1916—Continued.

1916.

State or territory.	Coal.	Wood.	Oil.	Natural gas.	Producer gas.	Coke.	Shavings.	Coal and wood.	Coal and Coak.	Total.
Alabama	7	6						20		33
Arizona		7								7
Arkansas		12								12
California		10	33		3					46
Colorado	6									6
Connecticut	5	27			4					36
Florida		16								16
Hawaii			2							2
Idaho		6				1				7
Illinois	2	5			2		[a] 9	11		29
Indiana	41	2			2					45
Iowa		5								5
Kansas	1									1
Kentucky	2	2			1			1		6
Maine	36	19								55
Maryland	48	3			1	[b] 49		8	23	131
Massachusetts	16	8			10			16		50
Michigan		23			1					24
Minnesota	7	5								12
Missouri	29	32			1			29		91
Montana		6								6
Nevada			2							2
New Jersey	19									19
New Mexico	3							1		4
New York	44	8			2			4		58
North Carolina								4		4
Ohio	224	7		[c] 32	49			5		317
Oklahoma		2								2
Oregon		3						2		5
Pennsylvania	618	34		1	6	92		39	64	854
Rhode Island	1	1								2
South Dakota	3	3								6
Tennessee	34	9						7		50
Texas	12	5	4	2		5				28
Utah	13	2				7				22
Vermont		4			5			7		16
Virginia	46	15			3	32		18		114
Washington		14								14
West Virginia	37	9				39		3		88
Wisconsin		115								115
Wyoming								1		1
	1,254	425	41	35	89	225	9	176	87	2,341

[a] Four kilns using also coal and wood.
[b] Three kilns using coke and wood.
[c] Two kilns using also coal and wood.

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MINERAL WATERS.[1]

By ARTHUR J. ELLIS.

CHARACTER OF STATISTICS.

The statistics given in this report have been compiled from individual reports furnished by the owners or operators of springs and include, so far as can be ascertained, only natural waters that are bottled and sold in their natural state or only slightly altered from their natural state. Natural still waters that have been artificially carbonated, natural carbonated waters that have lost part of their carbon dioxide, and waters from which iron has been removed are included; but artificial waters and natural waters that have been flavored, concentrated, fortified, diluted, or otherwise essentially modified in chemical character are excluded if available information indicates such treatment. Water given away or consumed at spring resorts, which constitutes a large part of the annual production, is excluded. Waters sold at flat or meter rates, delivered to consumers through pipes, or otherwise obviously municipal supplies or adjuncts to them are excluded. This is the nearest practicable conformity with the commonly accepted definition of natural mineral water. No distinction is made between mineral water flowing or pumped from a natural spring and that flowing or pumped from a dug, bored, driven, or drilled well. Many of the best-known mineral waters in the United States come not from natural springs but from wells.

Distinction for statistical purposes between table and medicinal waters is entirely arbitrary. Most table waters are clear, sparkling, and without distinct mineral taste or odor; many medicinal waters are highly mineralized and have distinct mineral taste and odor. Yet some table waters are more strongly mineralized than some medicinal waters, and many medicinal waters contain less mineral matter than certain city supplies. The basis here used for distinguishing medicinal from table waters is the report regarding the spring, and this distinction is based in turn on the operator's knowledge that some of his customers buy the water to use regularly on their tables and others buy it for an aid during illness. A few strongly mineralized waters are not sold as table waters, and a few widely sold table waters are not used medicinally, but many waters are sold for both uses, though the reported sales of several medicinal waters have distinctly decreased in the last few years.

[1] The statistics in this chapter were compiled by Miss B. H. Stoddard, of the United States Geological Survey.

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MINERAL-WATER TRADE IN 1916.

OUTPUT AND VALUE.

The number of active mineral springs was slightly smaller, but the production and value were greater in 1916 than in 1915. The increase in production was 3,814,958 gallons, or 7 per cent. The increase in value of medicinal waters was $61,522 and in value of table waters was $534,719; thus the total increase in value of sales was $596,241, or 12 per cent.

The State of New York led in number of commercial springs and in quantity of mineral water sold and was second to Wisconsin in total value of production and in the value of table waters; it ranked only sixth in value of medicinal waters, in which California and Indiana retained first and second place, respectively. Virginia and Texas were also heavy producers of medicinal waters. In value of table waters Wisconsin and New York were followed in order by California, Maine, Minnesota, and Connecticut; and in total value of production Wisconsin and New York were followed in order by California, Maine, Virginia, and Indiana. More than 30 springs were active in each of 10 States, more than 1,000,000 gallons of mineral water was sold in each of 16 States, and the value of the water sold amounted to more than $100,000 in each of 16 States.

Sales were reported from 802 springs in 1916, as compared with 812 springs in 1915. No reports of mineral-water sales were received from Arizona or Idaho, and less than 3 active springs were reported from Delaware, District of Columbia, and Utah; 3 or more springs were active in every other State in the Union. Sales exceeded 5,000,000 gallons in New York and Wisconsin, and in Wisconsin the total production was valued at more than $1,000,000. The total value of the output exceeded $500,000 in Wisconsin, New York, and California.

Mineral waters sold in the United States, 1915 and 1916.

State.	Commercial springs.	Quantity sold.	Average price per gallon.	Value of medicinal waters.	Value of table waters.	Total value.
1915.		*Gallons.*	*Cents.*			
Alabama	14	86,499	10	$8,213	$699	$8,912
Arkansas	13	1,377,093	9	70,862	48,210	119,072
California	50	2,789,871	19	206,181	326,636	532,817
Colorado	14	858,185	7	6,543	56,561	63,104
Connecticut	38	1,774,213	6	5,991	95,979	101,970
Florida	7	118,920	11	1,476	11,040	12,516
Georgia	19	746,068	7	9,207	44,572	53,779
Illinois	23	1,559,489	5	5,382	69,908	75,290
Indiana	18	542,053	35	172,215	16,859	189,074
Iowa	8	198,739	9	7,252	11,282	18,534
Kansas	14	155,938	40	59,721	3,348	63,069
Kentucky	11	459,841	14	47,300	15,978	63,278
Louisiana	5	513,838	6	3,307	27,464	30,771
Maine	24	1,115,648	30	89,148	248,855	338,003
Maryland	10	1,433,406	7	0	105,581	105,581
Massachusetts	48	3,872,192	5	14,598	169,535	184,133
Michigan	19	913,765	8	5,165	67,546	72,711
Minnesota	17	3,493,887	4	1,197	135,062	136,259
Mississippi	11	259,370	18	44,460	1,179	45,639
Missouri	33	1,000,961	8	65,394	17,969	83,363
Montana	3	114,245	6	55	6,548	6,603
Nebraska	3	8,770	11	145	817	962
Nevada	3	303,150	1	0	4,294	4,294
New Hampshire	7	176,385	4	875	5,862	6,737

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Mineral waters sold in the United States, 1915 and 1916—Continued.

State.	Commercial springs.	Quantity sold.	Average price per gallon.	Value of medicinal waters.	Value of table waters.	Total value.
1915—Continued.		*Gallons.*	*Cents.*			
New Jersey	13	1,479,479	8	2,520	113,706	116,226
New Mexico	4	42,400	16	4,370	2,310	6,680
New York	75	8,411,616	8	74,023	637,674	711,697
North Carolina	17	132,813	14	14,907	3,838	18,745
North Dakota	3	475,000	2	750	8,000	8,750
Ohio	36	3,504,343	4	10,923	122,493	133,416
Oklahoma	13	890,392	3	5,860	18,145	24,005
Oregon	7	28,747	30	1,942	6,787	8,729
Pennsylvania	47	2,136,218	8	11,733	163,065	174,798
Rhode Island	6	385,624	6	0	24,574	24,574
South Carolina	11	480,051	14	61,452	6,417	67,869
South Dakota	3	176,000	5	0	9,360	9,360
Tennessee	23	703,566	6	21,584	17,720	39,304
Texas	29	835,142	12	99,700	390	100,090
Vermont	5	61,540	23	4,250	10,132	14,382
Virginia	50	3,027,528	8	108,943	128,875	237,818
Washington	5	158,865	7	6,150	5,553	11,703
West Virginia	9	314,909	16	19,751	30,520	50,271
Wisconsin	36	4,861,734	22	81,395	970,010	1,051,405
Wyoming	5	68,584	13	4,000	5,059	9,059
Other States a	3	66,426	5	3	3,439	3,442
	812	52,113,503	10	1,358,943	3,779,851	5,138,794
1916.						
Alabama	16	103,944	12	5,979	6,195	12,174
Arkansas	13	1,152,505	9	56,623	43,993	100,616
California	55	2,651,471	19	206,853	296,922	503,775
Colorado	12	542,195	22	6,301	114,208	120,509
Connecticut	34	2,837,878	5	1,920	131,848	133,768
Florida	7	202,970	8	1,424	14,252	15,676
Georgia	18	618,367	7	5,429	39,781	45,210
Illinois	21	1,777,741	5	7,765	86,291	94,056
Indiana	17	609,544	31	169,545	19,100	188,645
Iowa	7	148,732	10	5,304	9,100	14,404
Kansas	12	237,790	25	53,076	5,716	58,792
Kentucky	11	377,246	14	38,664	13,641	52,305
Louisiana	4	429,650	7	2,918	28,150	31,068
Maine	24	1,038,861	34	90,643	263,149	353,792
Maryland	9	1,312,788	8	5,000	94,020	99,020
Massachusetts	51	3,124,096	4	15,613	112,865	128,478
Michigan	18	996,875	11	7,209	101,658	108,867
Minnesota	18	4,188,434	3	555	145,027	145,582
Mississippi	12	399,248	12	47,409	1,030	48,439
Missouri	36	1,394,092	8	74,828	34,986	109,814
Montana	4	181,800	7	1,000	11,294	12,294
Nebraska	3	8,440	11	74	872	946
Nevada	3	346,260	1	12	4,148	4,160
New Hampshire	6	269,860	6	38	14,897	14,935
New Jersey	15	1,580,028	8	3,100	127,893	130,993
New Mexico	4	35,450	11	5	3,960	3,965
New York	68	7,746,490	9	86,713	610,937	697,650
North Carolina	19	137,817	14	12,923	6,087	19,010
North Dakota	6	766,000	2	750	13,750	14,500
Ohio	37	4,102,922	4	60,263	100,897	161,160
Oklahoma	13	1,353,513	3	3,705	36,484	40,189
Oregon	6	30,920	26	1,076	6,885	7,961
Pennsylvania	42	1,671,637	9	21,898	123,235	145,133
Rhode Island	6	449,453	7	0	33,050	33,050
South Carolina	10	427,905	15	59,111	4,707	63,818
South Dakota	5	470,725	4	52	20,460	20,512
Tennessee	20	799,346	6	27,920	20,496	48,416
Texas	30	703,002	14	95,885	1,628	97,513
Vermont	5	72,590	21	4,310	11,085	15,395
Virginia	50	2,313,616	11	128,747	120,159	248,906
Washington	4	151,528	6	1,821	7,655	9,476
West Virginia	9	287,466	16	17,487	29,199	46,686
Wisconsin	36	7,696,813	20	76,979	1,430,700	1,507,679
Wyoming	3	53,891	13	2,000	5,269	7,269
Other States b	3	126,572	15	11,538	6,891	18,429
	802	55,928,461	10	1,420,465	4,314,570	5,735,035

a Includes Delaware and Utah.
b Includes Delaware, District of Columbia, and Utah.

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CONDITION OF TRADE.

The total production (quantity and value) in 1916 exceeded that of 1915, but the production of 1912 was not equaled. The statistics of production in the United States during the last five years are shown in the following table:

Mineral waters sold in the United States, 1912–1916.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1912	746	62,281,201	$6,615,671	11
1913	838	57,867,399	5,631,391	10
1914	829	54,358,466	4,892,328	9
1915	812	52,113,503	5,138,794	10
1916	802	55,928,461	5,735,085	10

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Comparative production of mineral waters, 1915–16.

State.	1915			1916			Increase or decrease in number of springs.	Increase or decrease in quantity sold.		Increase or decrease in value of product.	
	Commercial springs.	Quantity sold.	Value.	Commercial springs.	Quantity sold.	Value.					
		Gallons.			*Gallons.*			*Gallons.*	*Per cent.*	*Dollars.*	*Per cent.*
Alabama	14	86,499	$8,912	16	103,944	$12,174	+ 2	+ 17,445	+ 20	+ 3,262	+ 37
Arkansas	13	1,377,093	119,072	13	1,152,505	100,616	0	− 224,588	− 16	− 18,456	− 15
California	50	2,789,871	532,817	55	2,651,471	503,775	+ 5	− 138,400	− 5	− 29,042	− 5
Colorado	14	858,185	63,104	12	542,185	120,509	− 2	− 316,000	− 37	+ 57,405	+ 91
Connecticut	38	1,774,213	101,970	34	2,837,878	133,768	− 4	+ 1,063,665	+ 60	+ 31,798	+ 31
Florida	7	118,920	12,516	7	202,970	15,676	0	+ 84,050	+ 71	+ 3,160	+ 25
Georgia	19	746,068	53,779	18	618,367	45,210	− 1	− 127,701	− 17	− 8,569	− 16
Illinois	23	1,559,489	75,290	21	1,777,741	94,056	− 2	+ 218,252	+ 14	+ 18,766	+ 25
Indiana	18	542,053	189,074	17	609,544	188,645	− 1	+ 67,491	+ 12	− 429	− 2
Iowa	8	198,739	18,534	7	148,732	14,404	− 1	− 50,007	− 25	− 4,130	− 22
Kansas	14	155,938	63,069	12	237,790	58,792	− 2	+ 81,852	+ 52	− 4,277	− 7
Kentucky	11	459,841	63,278	11	377,246	52,305	0	− 82,595	− 18	− 10,973	− 17
Louisiana	5	513,838	30,771	4	429,650	31,068	− 1	− 84,188	− 16	+ 297	+ 1
Maine	24	1,115,648	338,003	24	1,038,861	353,792	0	− 76,787	− 7	+ 15,789	+ 5
Maryland	10	1,433,406	105,581	9	1,312,788	99,020	− 1	− 120,618	− 8	− 6,561	− 6
Massachusetts	48	3,872,192	184,133	51	3,124,096	128,478	+ 3	− 748,096	− 19	− 55,655	− 30
Michigan	19	913,765	72,711	18	996,875	108,867	− 1	+ 83,110	+ 9	+ 36,156	+ 50
Minnesota	17	3,493,887	136,259	18	4,188,434	145,582	+ 1	+ 694,547	+ 20	+ 9,323	+ 7
Mississippi	11	259,370	45,639	12	399,248	48,439	+ 1	+ 139,878	+ 54	+ 2,800	+ 6
Missouri	33	1,000,961	83,363	36	1,394,092	109,814	+ 3	+ 393,131	+ 39	+ 26,451	+ 32
Montana	3	114,245	6,603	4	181,800	12,294	+ 1	+ 67,555	+ 59	+ 5,691	+ 86
Nebraska	3	8,770	962	3	8,440	946	0	− 330	− 4	− 16	− 2
Nevada	3	303,150	4,294	3	346,260	4,160	0	+ 43,110	+ 14	− 134	− 3
New Hampshire	7	176,385	6,737	6	269,860	14,935	− 1	+ 93,475	+ 53	+ 8,198	+ 122
New Jersey	13	1,479,479	116,226	15	1,580,028	130,993	+ 2	+ 100,549	+ 7	+ 14,767	+ 13
New Mexico	4	42,400	6,680	4	35,450	3,965	0	− 6,950	− 16	− 2,715	− 41
New York	75	8,411,616	711,697	68	7,746,490	697,650	− 7	− 665,126	− 8	− 14,047	− 2
North Carolina	17	132,813	18,745	19	137,817	19,010	+ 2	+ 5,004	+ 4	+ 265	+ 1
North Dakota	3	475,000	8,750	6	766,000	14,500	+ 3	+ 291,000	+ 61	+ 5,750	+ 66
Ohio	36	3,504,343	133,416	37	4,102,922	161,160	+ 1	+ 598,579	+ 17	+ 27,744	+ 21
Oklahoma	13	890,392	24,005	13	1,353,513	40,189	0	+ 463,121	+ 52	+ 16,184	+ 67
Oregon	7	28,747	8,729	6	30,920	7,961	− 1	+ 2,173	+ 8	− 768	− 9
Pennsylvania	47	2,136,218	174,798	42	1,671,637	145,133	− 5	− 464,581	− 22	− 29,665	− 17
Rhode Island	6	385,624	24,574	6	449,453	33,050	0	+ 63,829	+ 17	+ 8,476	+ 35
South Carolina	11	480,051	67,869	10	427,905	63,818	− 1	− 52,146	− 11	− 4,051	− 6
South Dakota	3	176,000	9,360	5	470,725	20,512	+ 2	+ 294,725	+ 168	+ 11,152	+ 119
Tennessee	23	703,566	39,304	20	799,346	48,416	− 3	+ 95,780	+ 14	+ 9,112	+ 23
Texas	29	835,142	100,090	30	703,002	97,513	+ 1	− 132,140	− 16	− 2,577	− 3

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Comparative production of mineral waters, 1915–16—Continued.

State.	1915			1916			Increase or decrease in number of springs.	Increase or decrease in quantity sold.		Increase or decrease in value of product.	
	Commercial springs.	Quantity sold.	Value.	Commercial springs.	Quantity sold.	Value.					
		Gallons.			*Gallons.*			*Gallons.*	*Per cent.*	*Dollars.*	*Per cent.*
Vermont	5	61,540	14,382	5	72,590	15,395	0	+ 11,050	+ 18	+ 1,013	+ 7
Virginia	50	3,627,528	237,818	50	2,313,616	248,906	0	− 713,912	− 24	+ 11,088	+ 5
Washington	5	158,865	11,703	4	151,528	9,476	− 1	− 7,337	− 5	− 2,227	− 19
West Virginia	9	314,909	50,271	9	287,466	46,686	0	− 27,443	− 9	− 3,585	− 7
Wisconsin	36	4,861,734	1,051,405	36	7,696,813	1,507,679	0	+ 2,835,079	+ 58	+ 456,274	+ 43
Wyoming	5	68,584	9,059	3	53,891	7,269	− 2	− 14,693	− 21	− 1,790	− 20
Other States[a]	3	66,426	3,442	3	126,572	18,429	0	+ 60,146	+ 91	+ 14,987	+ 435
	812	52,113,503	5,138,794	802	55,928,461	5,735,035	−10	+ 3,814,958	+ 7	+ 596,241	+ 12

[a] Includes in 1915 Delaware and Utah; in 1916, Delaware, District of Columbia, and Utah.

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RANGE OF PRICE.

Effort has been made in compiling the following table, which gives the quantity and value of mineral water sold within certain ranges of price during 1915 and 1916, to eliminate freight and marketing charges and the value of returnable containers, and thus to give the net value of the waters at their sources:

Range of price per gallon of mineral water, 1915–16.

Price per gallon (in cents).	Number of springs.	Quantity sold (gallons).	Value.	Percentage of number of springs.	Percentage of total quantity.	Percentage of total value.
1915.						
Not more than 2	56	7,281,647	$93,930	7	14	2
More than 2 and not more than 5	211	16,119,591	632,103	27	31	12
More than 5 and not more than 10	249	19,096,994	1,570,186	32	37	31
More than 10 and not more than 20	138	4,628,897	710,330	17	9	14
More than 20 and not more than 30	59	1,197,670	291,703	7	2	6
More than 30 and not more than 50	49	2,897,830	1,151,055	6	5	22
More than 50 and not more than 100	24	811,753	574,654	3	2	11
More than 100	8	79,121	114,863	1	0	2
	[a] 794	52,113,503	5,138,794	100	100	100
1916.						
Not more than 2	44	12,507,685	$214,831	6	22.4	4
More than 2 and not more than 5	184	13,392,955	529,188	23	23.9	9
More than 5 and not more than 10	259	18,758,900	1,519,313	33	33.5	27
More than 10 and not more than 20	136	5,286,014	817,045	17	9.5	14
More than 20 and not more than 30	60	1,326,572	330,467	8	2.4	6
More than 30 and not more than 50	63	3,647,317	1,511,138	8	6.5	26
More than 50 and not more than 100	29	864,638	621,939	4	1.5	11
More than 100	9	144,380	191,114	1	.3	3
	[a] 784	55,928,461	5,735,035	100	100.0	100

[a] Exclusive of 18 springs whose waters are used exclusively in the manufacture of soft drinks.

Practically four-fifths of the mineral waters was sold at prices ranging from one-half cent to 10 cents a gallon during 1913, 1914, 1915, and 1916. The percentage sold for more than 30 cents a gallon was nearly double what it was in 1915 and constituted a little more than 8 per cent of the quantity sold in 1916. The water from 487 springs was sold for 10 cents or less a gallon, and the water from 9 springs was sold for more than $1 a gallon. The average price per gallon in 1916 was 10 cents.

SOFT DRINKS.

Returns show that the quantity of mineral water used in the manufacture of soft drinks during 1916 was 23 per cent greater than that used during 1915. The gross distribution of the consumption during 1916 is indicated in the following table. Wisconsin and Massachusetts head the list with consumptions greater than 1,000,000 gallons. In addition to these 15 States reported consumption exceeding 100,000 gallons of mineral water used in the manufacture of soft drinks during 1916, and 22 other States reported a combined consumption of 739,666 gallons. This recorded consumption does not represent the total production of soft drinks in the United States, as most of them are compounded with municipal and private supplies not classified as mineral waters.

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Mineral water used in the manufacture of soft drinks, 1916.

Rank.	State.	Quantity.	Rank.	State.	Quantity.
		Gallons.			*Gallons.*
1	Wisconsin	1,500,917	11	Iowa	186,081
2	Massachusetts	1,032,815	12	Maine	184,103
3	Minnesota	506,738	13	New York	182,907
4	Connecticut	481,936	14	Ohio	168,200
5	Pennsylvania	337,635	15	Maryland	138,247
6	New Hampshire	313,881	16	California	134,333
7	South Carolina	303,150	17	Illinois	106,340
8	Colorado	302,121		Other States	739,666
9	Nebraska	205,600			
10	Arkansas	200,000			7,024,670

EXPORTS.

Large quantities of a few domestic waters are exported, but no statistics regarding such shipments are available. The quantity and the value of these waters are included in the statistics of production for the United States.

IMPORTS.

The total imports of natural and artificial waters entered for consumption in 1916, as reported by the Bureau of Foreign and Domestic Commerce, Department of Commerce, amounted to 1,172,440 gallons, valued at the points of shipment at $624,302. This was a decrease of 23 per cent in quantity, but owing to an increase of 17 cents in the average price per gallon—the average price in 1916 being 53 cents as compared with 36 cents in 1915—there was an increase in total value of imported waters of 13 per cent. The imports have decreased in quantity every year since 1911. A table showing general imports by principal countries is given on page 501.

Mineral waters imported for consumption in the United States, 1912–1916.

Year.	Quantity.	Value.	Price per gallon.
	Gallons.		*Cents.*
1912	3,499,497	$930,091	27
1913	3,364,676	955,788	28
1914	2,786,142	857,707	31
1915	1,528,181	551,648	36
1916	1,172,440	624,302	53

MINERAL-WATER TRADE BY STATES.

ALABAMA.

Returns from Alabama indicate that the mineral-water trade in 1916 was about 20 per cent more than that in 1915. The sales amounted to 103,944 gallons, and the value of the output was $12,174, the average price per gallon increasing from 10 cents to 12 cents. There was a considerable decrease in the value of the output of medicinal waters, but the large increase in the sales of table waters netted a gain of $3,262 in the total sales. Sixteen springs reported sales. One spring which was active in 1915 reported no sales for

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1916. Gordon Mineral Springs is newly added to the list. Seven mineral-water bathing establishments and 5 resorts, accommodating about 800 guests, were maintained. The quantity of mineral water used in the manufacture of soft drinks increased from 2,300 gallons to 13,500 gallons.

The following 16 springs reported sales:

Bailey Springs, Florence, Lauderdale County.
Bladon Springs, Bladon Springs, Choctaw County.
Blount Springs, Blount Springs, Choctaw County.
Bromberg Gulf Coast Lithia Spring, Bayou Labatre, Mobile County.
Cooks Springs, Cooks Springs, St. Clair County.
Dixie Spring, Dixie Spring, Walker County.
Gordon Mineral Springs, Canoe, Escambia County.
Healing Springs, Healing Springs, Washington County.
Livingston Mineral Well, Livingston, Sumter County.
Luverne Mineral Spring, Luverne, Crenshaw County.
McCary Mineral Well, near Birmingham, Jefferson County.
Matchless Mineral Water Well, east of Greenville, Butler County.
Purity Spring, Spring Hill, Mobile County.
Shocco Springs, Talladega, Talladega County.
Talladega Springs, Talladega Springs, Talladega County.
White Sulphur Wells, near Jackson, Clarke County.

ARKANSAS.

The sales of mineral water in Arkansas during 1916 were 1,152,505 gallons, as reported from 13 active springs, a decrease of a little more than 16 per cent below the output in 1915. The average price of the water, 9 cents, remained the same, and the total value of the output amounted to $100,616, which is 15 per cent less than the total value of sales in 1915. The sales of both medicinal and table waters showed an appreciable falling off.

Three springs which were idle in 1915 reported sales in 1916. One spring which sold water in 1915 is reported to be no longer in business. Of two other springs which reported sales in 1915, one was reported idle in 1916 and the other was not heard from.

Five resorts, accommodating about 5,980 guests, exclusive of Hot Springs, and 3 bathing establishments were maintained, in addition to which 200,000 gallons of mineral water, as compared with 100,000 gallons used in 1915, was used in the manufacture of soft drinks.

Mineral waters sold in Arkansas, 1912–1916.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1912	11	1,396,032	132,257	10
1913	16	1,428,869	151,412	11
1914	18	1,314,159	115,205	9
1915	13	1,377,093	119,072	9
1916	13	1,152,505	100,616	9

The 13 springs reporting sales are as follows:

Arkansas Lithia Springs, Hope, Hempstead County.
Arsenic Spring, Hot Springs, Garland County.
Chewaukla Spring, Hot Springs, Garland County.
Glenaqua Mineral Spring, Hot Springs, Garland County.
Happy Hollow Springs, Hot Springs, Garland County.
Iron and Magnesia Springs, Hot Springs, Garland County.

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Lithia and Sulphur Springs, Sulphur Springs, Benton County.
Mountain Blood Spring, near Hot Springs, Garland County.
Mountain Valley Springs, Mountain Valley, Garland County.
Oaklawn Mineral Well, Hot Springs, Garland County.
Ozarka Spring, Eureka Springs, Carroll County.
Potash Sulphur Springs, Lawrence, Garland County.
Raleigh Springs, Little Rock, Pulaski County.

CALIFORNIA.

The output of mineral water in California during 1916 showed a decrease of 5 per cent in quantity and 5 per cent in value, as compared with the output in 1915.

The total quantity sold was 2,651,471 gallons. The sales of medicinal waters yielded $206,853 and table waters $296,922—a total of $503,775, the average price being 19 cents, as in 1915.

Three new producers—the Arrowhead Springs, in San Bernardino County; the Bartlett Springs, in Lake County; and Cold Spring, in Santa Barbara County—were reported for the first time. California Geysers is now called Magnesia Springs, and Napa Vichy Springs are now called Lepori Vichy Springs. The outputs of 2 springs from which no reports could be obtained have been estimated. The number of active springs was 55, of which 4 were idle in 1915. Mineral-water baths were maintained at 17 springs, and 22 resorts, accommodating about 4,000 guests, were operated. In the manufacture of soft drinks 134,383 gallons of mineral water was used.

Mineral waters sold in California, 1912–1916.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1912	41	2,089,951	$532,971	26
1913	49	2,801,393	531,925	19
1914	48	2,282,569	497,923	22
1915	50	2,789,871	532,817	19
1916	55	2,651,471	503,775	19

The 55 springs reporting production are as follows:

Adams Springs, Adams, Lake County.
Ætna Spring, Lidell, Napa County.
Agua Caliente Springs, Agua Caliente, Sonoma County.
Alder Glen Springs, Cloverdale, Sonoma County.
Alhambra Springs, near Martinez, Contra Costa County.
Alma Spring, Alma, Santa Clara County.
Arrowhead Springs, Arrowhead Springs, San Bernardino County.
Barcal Springs, Preston, Sonoma County.
Bartlett Springs, Bartlett Springs, Lake County.
Beulah Springs, Riverside, Riverside County.
Bimini Hot Springs, Los Angeles, Los Angeles County.
Boyes Hot Springs, Boyes Springs, Sonoma County.
Busch Springs, Potter Valley, Mendocino County.
Bythinia Well, Santa Barbara, Santa Barbara County.
Calavichy Springs, Willits, Mendocina County.
Castalian Water, Keeler, Inyo County.
Castle Rock Mineral Springs, Eubanks, Shasta County.
Cold Spring, Santa Barbara, Santa Barbara County.
Console Mineral Springs, Colton, Riverside County.
Cooks Springs, near Williams, Colusa County.
Crystal Spring, Los Angeles, Los Angeles County.
Deerlick Springs, Deer Lick Springs, Trinity County.

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El Granito Mineral Spring, El Cajon, San Diego County.
Elliotta Spring, Riverside, Riverside County.
Elysian Spring, Los Angeles, Los Angeles County.
Grizzly Springs, near Sulphur Creek, Lake County.
Holly Spring, Hollywood, Los Angeles County.
Iaqua Medicinal Spring, Eureka, Humboldt County.
Lepori Vichy Springs, near Napa, Napa County.
Magnesia Spring, The Geysers, Sonoma County.
Marin Mountain Spring, Sausalito, Marin County.
McGlashan Mineral Spring, near Truckee, Placer County.
Mok-Hill Mineral Spring, Mokelumne Hill, Calaveras County.
Monterey Mineral Well, Monterey, Monterey County.
Napa Rock Spring, Soda Valley, Napa County.
Napa Soda Springs, Napa Soda Springs, Napa County.
Nuvida Spring, La Pressa, San Diego County.
Polk Springs, Butte Meadows, Tehama County.
Pope Mineral Spring, Pope Valley, Napa County.
Radium Sulphur Springs, Colegrove, Los Angeles County.
Redwing Springs, Middletown, Lake County.
Richardsons Springs, Chico, Butte County.
Rose Spring, Los Angeles, Los Angeles County.
Samuel Soda Springs, Monticello, Napa County.
San Benito Mineral Well, near Hollister, San Benito County.
Shanghai Spring, Sausalito, Marin County.
Shasta Spring, Shasta Springs, Siskiyou County.
Tamalpais Mineral Well, San Rafael, Marin County.
Tolenas Spring, near Suisun, Solano County.
Upper Soda Springs, Dunsmuir, Siskiyou County.
Valley Springs, Valley Springs, Calaveras County.
Veronica Medicinal Springs, near Santa Barbara, Santa Barbara County.
Walters Springs, Pope Valley, Napa County.
Wheelers Hot Springs, Wheeler Springs, Ventura County.
Witter Medical Spring, Witter Springs, Lake County.

COLORADO.

Returns from Colorado for 1916 indicate a greater decrease in quantity of mineral water sold than was reported in 1915, the decrease being nearly 37 per cent, as against 11 per cent in 1915. But there was an increase of 15 cents in the average price received for the water, the price being 22 cents in 1916, and a consequent increase of 91 per cent in the total value of sales. The increase in price was due chiefly to two firms, one having changed management and probably selling water by the gallon instead of in bulk, and the other having raised the price of its product. The sales of medicinal waters remained about the same as in 1915, but there was a large gain in the sales of table waters.

Reports were received from 12 active springs—2 less than in 1915. Four bathing establishments were maintained—the same number as in 1915—and 3 resorts, accommodating about 850 guests. In the manufacture of soft drinks 302,121 gallons of water was used.

Mineral waters sold in Colorado, 1912–1916.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1912	11	1,178,308	$75,314	6
1913	11	1,053,429	89,520	9
1914	12	968,260	113,413	12
1915	14	858,185	63,104	7
1916	12	542,185	120,509	22

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The 12 springs regarding which reports were received are as follows:

Boulder Springs, Boulder Springs, Boulder County.
Canon City Soda Springs, Canon City, Fremont County.
Clark's Well, Pueblo, Pueblo County.
Columbia Well, Denver, Denver County.
Green Mineral Well, Canon City, Fremont County.
Horn Mineral Springs, Colorado Springs, El Paso County.
Navajo, Shoshone, Manitou, and Cheyenne springs, Manitou, El Paso County.
Pueblo Mineral Springs, Pueblo, Pueblo County.
Ute Chief Manitou Spring, Manitou, El Paso County.
Ute, Iron, Ouray, and Geyser Iron springs, Manitou, El Paso County.
Waunita Hot Springs, Waunita Hot Springs, Gunnison County.
Yampah Spring, Glenwood Springs, Garfield County.

CONNECTICUT.

The output of mineral water in Connecticut increased 60 per cent in quantity and 31 per cent in value in 1916, and the average price per gallon decreased from 6 cents to 5 cents. In 1915 a decrease in the sales of table waters and a 100 per cent increase in the sales of medicinal waters was reported, but the returns for 1916 show a very decided decrease—from $5,991 in 1915 to $1,920 in 1916—in the value of medicinal waters, and as decided an increase—from $95,979 in 1915 to $131,848 in 1916—in the value of table waters sold. The total value of sales in 1916 was $133,768.

Pequot Spring, situated near Glastonbury, reported for the first time, making a total of 34 active springs reported, or 4 less than in 1915. No reports were received from 3 springs on the list, but estimates were made for 2 of these. Stillson Springs are now reported under the name Rock Springs. No resorts of mineral-water baths were reported, but about 481,936 gallons of mineral water was used in the manufacture of soft drinks, a gain of 161,467 gallons over the quantity used in 1915.

Mineral waters sold in Connecticut, 1912–1916.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1912	28	2,110,231	$153,383	7
1913	43	2,458,327	136,878	6
1914	42	2,341,062	134,478	6
1915	38	1,774,213	101,970	6
1916	34	2,837,878	133,768	5

The 34 springs for which production was reported are as follows:

Althea Spring, Waterbury, New Haven County.
Arethusa Spring, Seymour, New Haven County.
Bailey Springs, Danbury, Fairfield County.
Barcla Springs, Danbury, Fairfield County.
Beaver Spring, Ansonia, New Haven County.
Berkshire Springs, Cornwall Bridge, Litchfield County.
Chalybeate Spring, Oxford, New Haven County.
Cherry Hill Spring, Highwood, New Haven County.
Crystal Spring, near Middletown, Middlesex County.

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Crystal Spring, near Derby, New Haven County.
Diamond Spring, Cheshire, New Haven County.
East Hill Spring, Derby, New Haven County.
Elco Springs, Bristol, Hartford County.
Ellis Mountain Spring, Danbury, Fairfield County.
Glacier Springs, Bridgeport, Fairfield County.
Granite Rock Spring, Haddam, Middlesex County.
Granite Rock Spring, Danbury, Fairfield County.
Gra-Rock Spring, Canton, Hartford County.
Hermitage Spring, Montowese, New Haven County.
Hillside Spring, West Meriden, New Haven County.
Hosmer Mountain Spring, Willimantic, Windham County.
Indian Spring, Huntington, Fairfield County.
Live Oak Spring, Meriden, New Haven County.
Mammanasco Spring, Ridgefield, Fairfield County.
Oak Spring, Middletown, Middlesex County.
Park Spring, Willimantic, Windham County.
Pequabuck Mountain Springs, Bristol, Hartford County.
Pequot Spring, Glastonbury, Hartford County.
Pequot Mineral Spring, Old Mystic, New London County.
Richardson Spring, Torrington, Litchfield County.
Rock Spring, Fairfield, Fairfield County.
Stafford Spring, Stafford Springs, Tolland County.
Varuna Spring, North Stamford, Fairfield County.
Venture Rock Spring, Stonington, New London County.

DELAWARE.

Reports have been received from only one spring in Delaware during the last six years, the water being used chiefly on the table by residents of Wilmington. The spring is called:

Kiamensi Springs, near Wilmington, Newcastle County.

DISTRICT OF COLUMBIA.

One spring in the District of Columbia reported sales during 1916. This spring is called:

Red Oak Spring, near Langdon.

FLORIDA.

Returns from Florida showed an increase of nearly 71 per cent in quantity and of 25 per cent in value of mineral water in 1916, as compared with 1915. Seven springs, the same number as reported in 1915, were active in 1916. One spring idle in 1915 was producing in 1916 and one spring active in 1915 reported no sales for 1916. The total output was 202,970 gallons, valued at $15,676. The average price per gallon decreased from 11 cents to 8 cents.

Five bathing establishments—2 more than in 1915—and 3 resorts, accommodating 640 persons, were maintained.

The number of active springs is 7, as follows:

Cedar Springs, Duval County.
Chumuckla Spring, Chumuckla, Santa Rosa County.
Espiritu Santo Springs, Safety Harbor, Pinellas County.
Magnesia Spring, near Grove Park, Alachua County.
Purity Spring, near Tampa, Hillsborough County.
Quisisana Spring, Green Cove Springs, Clay County.
Stomawa Well, near Tampa, Hillsborough County.

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GEORGIA.

The sales of mineral water in Georgia decreased 17 per cent in quantity and 16 per cent in value during 1916, and the price per gallon remained at 7 cents. The production was 618,367 gallons, valued at $45,210. There was a drop in the output of both medicinal and table waters. Four bathing establishments and three resorts accommodating 800 guests were maintained at springs. The number of active springs dropped from 19 to 18. Two springs idle in 1915 reported sales for 1916, and three springs active in 1915 were idle in 1916. White Elk Spring is now called St. Winifred's Spring.

The names and locations of the 18 springs that reported sales in 1916 are given in the appended list:

Benscot Mineral Springs, Austell, Cobb County.
Bowden Springs, Lithia Springs, Douglas County.
Catoosa Springs, Catoosa Springs, Catoosa County.
Chalybeate Springs, Chalybeate, Meriwether County.
Cliff Rock Spring, Fulton County.
Dalton Mineral Spring, Dalton, Whitfield County
Flake Hill Spring, Debruce, Richmond County.
High Point Mineral Wells, Macon, Bibb County.
High Rock Spring, near Atlanta, Fulton County.
Jay Bird Spring, near Helena, Dodge County.
Millers Mineral Spring, Milledgeville, Baldwin County.
Murrow Springs, Tifton, Tift County.
Panther Springs, near Augusta, Richmond County.
Pine Mountain Spring, near West Point, Harris County.
St. Winifred's Spring, near Macon, Bibb County.
Utoy-Flora Spring, Utoy Spring, Fulton County.
White Oak Mineral Wells, Macon, Bibb County.
Windsor Spring, near Augusta, Richmond County.

ILLINOIS.

The production of mineral water in Illinois increased 14 per cent in quantity and 25 per cent in value in 1916. The output of both medicinal and table waters increased appreciably. The total sales were 1,777,741 gallons, valued at $94,056, of which $7,765 was received for medicinal waters and $86,291 for table waters. The number of active springs decreased from 23 to 21. Two springs which were marketing water in 1915 were reported out of business. Tus-Ka-Walla Spring was given the new name of Walla Watta Well. One spring active in 1915 reported no sales for 1916, and a report of sales was received from one spring idle in 1915.

The quantity of mineral water used in the manufacture of soft drinks decreased from 267,880 gallons to 106,340 gallons. Resorts for about 750 guests were maintained at five springs, and mineral-water bathing establishments were maintained at nine springs, the same as in 1915.

Mineral waters sold in Illinois, 1912–1916.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1912	17	1,143,625	$74,445	7
1913	21	1,216,442	68,549	6
1914	21	1,760,020	81,207	5
1915	23	1,559,489	75,290	5
1916	21	1,777,741	94,056	5

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Sales were reported from the following 21 springs:

Abana Mineral Springs, Libertyville, Lake County.
Ams Well, Alton, Madison County.
Central Park Sulphur Springs, Peoria, Peoria County.
Diamond Mineral Springs, Grantfork, Madison County.
Glen Flora Mineral Springs, Waukegan, Lake County.
Glen Rock Mineral Spring, Waukegan, Lake County.
Gravel Springs, near Jacksonville, Morgan County.
Indian Spring, Streator, Lasalle County.
Marilla Spring, Streator, Lasalle County.
Minerva Spring, Cary Station, McHenry County.
Mokena Mineral Spring, Mokena, Will County.
Montgomery Magnesia Spring, Montgomery, Kane County.
Na-mon-o-ma and Old Ironsides Springs, Dixon Springs, Pope County.
Pekin Mineral Spring, Pekin, Tazewell County.
Perry Mineral Spring, Perry, Pike County.
Ripley Mineral Spring, near Ripley, Brown County.
Sanicula Mineral Springs, South Ottawa, Lasalle County.
Stablers Medicinal Spring, Kewanee, Henry County.
Sulphur Lick Spring, Wedron, Lasalle County.
Walla Watta Well, Cordova, Rock Island County.
Woodmen Artesian Well. Rock Island, Rock Island County.

INDIANA.

Indiana produced 609,544 gallons of mineral waters in 1916—12 per cent more than in 1915—valued at $188,645, practically the same as the value for 1915. The average price per gallon was reduced from 35 cents to 31 cents. There was a considerable decrease in the sales of medicinal waters and a moderate increase in the sales of table waters. One spring which reported in 1915 failed to report for 1916, leaving a record of 17 active springs in 1916. Six bathing establishments and 8 resorts, accommodating 2,187 guests, were maintained.

The following 17 springs reported sales:

Artesian Mineral Spring, Martinsville, Morgan County.
Blue Cast Well, Woodburn, Allen County.
Bronson Well, Terre Haute, Vigo County.
Carlson's Mineral Springs, Laporte, Laporte County.
Cartersburg Spring, Cartersburg, Hendricks County.
Colomagna Mineral Springs, Columbus, Bartholomew County.
Greenwood Springs, Fort Wayne, Allen County.
Holman Mineral Well, Crawfordsville, Montgomery County.
Knotts Mineral Springs, Porter, Porter County.
McCullough Springs, Oakland City, Gibson County.
Martinsville Spring, Martinsville, Morgan County.
Paoli Lithia Springs, Paoli, Orange County.
Paynes Saline Sulphur Wells, Henryville, Clark County.
Pluto, Proserpine, and Bowles springs, French Lick, Orange County.
Reid Mineral Spa Lithia Springs, near Richmond, Wayne County.
West Baden Mineral Springs, West Baden, Orange County.
White Crane Well, Dillsboro, Dearborn County.

IOWA.

The reported output of mineral water in Iowa during 1916 was 148,732 gallons, sold for $14,404, as compared with 198,739 gallons, sold for $18,534, in 1915. These figures correspond to decreases in quantity and value, respectively, of 25 and 22 per cent. The average price per gallon increased from 9 to 10 cents. One spring which reported sales in 1915 was idle in 1916. Colfax Grand Spring is now called Grand Hotel Mineral Spring, and Hawkeye Hygeia Spring is

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now known as Hygeia Well. More than 186,000 gallons of mineral water was used in the manufacture of soft drinks. One mineral-water bathing establishment and two resorts were maintained.

The 7 springs reporting sales are as follows:

Colfax Mineral Spring, Colfax, Jasper County.
Egralharve Spring, Montgomery, Dickinson County.
Grand Hotel Mineral Spring, Colfax, Jasper County.
Hestons Spring, Jefferson County.
Hygeia Well, Sioux City, Woodbury County.
Red Mineral Springs, Eddyville, Wapello County.
White Sulphur Spring, Linwood, Scott County.

KANSAS.

The mineral-water business in Kansas during 1916 showed an increase in quantity, but a decrease in value. The total sales amounted to 237,790 gallons—52 per cent more than in 1915—valued at $58,792, which is 7 per cent less than the value of the sales in 1915. The average price per gallon dropped from 40 to 25 cents. The sales of medicinal waters showed a marked decrease, but there was a considerable gain in the sales of table waters. Three springs active in 1915 were idle in 1916, and one spring idle in 1915 reported sales in 1916, making a total of 12 active in 1916. Mineral-water bathing establishments accommodated 552 guests at 3 resorts, and 5 bathing establishments were maintained.

The following 12 springs reported sales:

Abilena Wells, Abilene, Dickinson County.
Aganippe Spring, near Independence, Montgomery County.
Blasing's Mineral Spring, near Manhattan, Riley County.
California Spring, Ottawa, Franklin County.
Crystal Spring, Coffeyville, Montgomery County.
Geuda Spring, Geuda Springs, Cowley County.
Geyser Mineral Springs, Rosedale, Wyandotte County.
Natures Best Spring, Conway Springs, Sumner County.
Riverview Mineral Spring, Winfield, Cowley County.
Sycamore Mineral Springs, Sabetha, Brown County.
Viola Springs, near Viola, Sedgwick County.
Waconda Springs, Waconda Springs, Mitchell County.

KENTUCKY.

The reports for 1916 show a small decline in the production of mineral water in Kentucky. There was a decrease of 18 per cent in quantity and 17 per cent in value. The reported sales in 1916 were 377,246 gallons, as compared with 459,841 gallons in 1915, and the value of the output was $52,305, as compared with $63,278 in 1915. The average price remained at 14 cents. One spring which marketed water in 1915 reported no sales in 1916; 1 spring which reported in 1915 was not heard from in 1916; and 2 springs idle in 1915 reported sales in 1916; thus the total number of active springs remained 11. Five resorts, accommodating more than 2,100 guests, inclusive of the capacity of Dawson Springs, and 2 mineral-water bathing establishments were maintained. In addition to this 34,560 gallons of mineral water was used in making soft drinks.

The 11 springs reporting production are as follows:

Anita Springs, La Grange, Oldham County.
Audubon Springs, Dover, Mason County.
Avon-More Well, Dry Ridge, Grant County.

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Cole's Lexington Lithia Springs, Lexington, Fayette County.
Glen Lily Lithia Wells, near Bowling Green, Warren County.
Hamby's Well, Dawson Springs, Hopkins County.
Kentucky Carlsbad Spring, Dry Ridge, Grant County.
Kentucky Mineral Well, Lorain, Taylor County.
Robson Spring, Fort Thomas, Campbell County.
Royal Magnesian Spring, near La Grange, Oldham County.
Sanders Lithia Spring, Sanders, Carroll County.

LOUISIANA.

Reports were received from 4 springs in Louisiana, which showed a total output of 429,650 gallons, valued at $31,068. This represents a decrease of 16 per cent in quantity and an increase of 1 per cent in value. The sales of medicinal waters decreased, whereas an increase is reported in the sales of table waters. The average price per gallon increased from 6 to 7 cents. One spring active in 1915 reported no sales during 1916. Two resorts for guests were operated.

Mineral waters sold in Louisiana, 1912–1916.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1912	4	561,660	$33,345	6
1913	5	700,795	39,657	6
1914	5	576,138	31,562	6
1915	5	513,838	30,771	6
1916	4	429,650	31,068	7

The 4 springs that made returns are as follows:

Abita Springs, Abita Springs, St. Tammany Parish.
Geyser Well, Hammond, Tangipahoa Parish.
Krotz Springs, Krotz Springs, St. Landry Parish.
Ozone Spring, Pearl River, St. Tammany Parish.

MAINE.

The output of mineral water in Maine was about the same in 1916 as in 1915, the number of active springs remaining 24. The average price per gallon increased from 30 to 34 cents. The mineral water used in the manufacture of soft drinks in 1915 was notably less than the quantity so used in 1914, but the returns for 1916 show a consumption of 184,103 gallons in that industry, which is about the same as the quantity reported for 1914. Two resorts for guests were maintained, but no bathing establishments using mineral water were reported. One spring, active in 1915, reported no sales in 1916, and one, idle in 1915, was active in 1916. The output of one spring, for which figures were not obtainable, was estimated.

The names and locations of the 24 springs from which reports of sales were received are given in the following list:

Arctic Spring, Bangor, Penobscot County.
Baker Puritan Spring, Pine Point, Cumberland County.
Forest Springs, Litchfield, Kennebec County.
Glenrock Cold Spring, Greene, Androscoggin County.
Glenwood Spring, Augusta, Kennebec County.
Glenwood Mineral Spring, St. Albans, Somerset County.

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Hanover Spring, Hanover, Oxford County.
Highland Spring, Lewiston, Androscoggin County.
Indian Hermit Spring, Wells, York County.
Kennebunk Mineral Spring, Kennebunk, York County.
Keystone Mineral Spring, East Poland, Androscoggin County.
Mount Desert Spring, Northeast Harbor, Hancock County.
Mount Zircon Spring, Milton Plantation, Oxford County.
Mystic Spring, Saco, York County.
Oak Grove Spring, Brewer, Penobscot County.
Pine Spring, Brunswick, Cumberland County.
Poland Mineral Spring, South Poland, Androscoggin County.
Purity Spring, West Scarboro, Cumberland County.
Redman Farm Spring, Belfast, Waldo County.
Rocky Hill Spring, Fairfield, Somerset County.
Sabattus Mountain Spring, Sabattus, Androscoggin County.
Skowhegan Crystal Spring, Skowhegan, Somerset County.
Thorndike Mineral Spring, near Thorndike, Waldo County.
Wawa Lithia Spring, Ogunquit, York County.

Mineral waters sold in Maine, 1912–1916.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1912	31	1,179,192	$432,765	37
1913	32	1,174,262	368,436	31
1914	29	1,082,631	333,234	31
1915	24	1,115,648	338,003	30
1916	24	1,038,861	353,792	34

MARYLAND.

Reports for 1916 show a further decline of 8 per cent in the quantity and 6 per cent in the value of mineral water produced in Maryland. There had been a decrease of 15 per cent both in quantity and value in 1915. The total sales in 1916 amounted to 1,312,788 gallons, valued at $99,020. In 1915 the output was entirely table water, but in 1916 the value of table water sold decreased from $105,581 to $94,020, and mineral water, valued at $5,000, was marketed for medicinal purposes. In addition to the quantity reported as sold, 138,247 gallons was used in the manufacture of soft drinks, as compared with 120,000 gallons used in this industry in 1915. The same springs reporting sales in 1915, except one reported out of business, were active in 1916, the total number being nine. One resort for guests was maintained, but no bathing establishments using mineral water.

Mineral waters sold in Maryland, 1912–1916.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1912	13	1,606,373	$157,541	10
1913	12	1,390,437	126,383	9
1914	10	1,691,776	124,403	7
1915	10	1,433,406	105,581	7
1916	9	1,312,788	99,020	8

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The 9 springs reporting sales are as follows:

Big Rock Spring, Frederick County.
Brooklandwood Springs, Brooklandville, Baltimore County.
Buena Vista Spring, Edgemont, Washington County.
Carroll Springs, Forest Glen, Montgomery County.
Caton Spring, Catonsville, Baltimore County.
Chattolanee Springs, Chattolanee, Baltimore County.
Mardela Mineral Spring, Mardela Springs, Wicomico County.
Powhatan Spring, Baltimore, Baltimore County.
Rock Crystal Spring, Rognel Heights, Baltimore County.

MASSACHUSETTS.

Returns from Massachusetts for 1916 indicate a decrease of 19 per cent in the quantity and 30 per cent in the value of mineral waters sold. The average price per gallon decreased from 5 to 4 cents. The sales amounted to 3,124,096 gallons, valued at $128,478. In addition to the quantity reported as sold, 1,032,815 gallons were used in the manufacture of soft drinks, as compared with 876,408 gallons used in that industry in 1915. The sale of medicinal waters increased, but there was an appreciable decline in the sale of table waters. Cascella Springs, near Three Rivers, Hampden County, is a new producer. One spring active in 1915 reported no sales in 1916, and 4 springs idle in 1915 were active in 1916. Leicester Polar Spring is now called Polar Spring. One small resort was maintained, but no mineral-water bathing establishments were reported.

Mineral waters sold in Massachusetts, 1912–1916.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1912	64	4,502,806	$247,397	6
1913	60	3,907,395	213,802	6
1914	52	3,084,385	174,324	6
1915	48	3,872,192	184,133	5
1916	51	3,124,096	128,478	4

The 51 reporting springs are as follows:

Abbotts Spring, Methuen, Essex County.
Avonia Spring, Weymouth, Norfolk County.
Ballardvale Springs, North Andover, Essex County.
Belmont Crystal Spring, Belmont, Middlesex County.
Burnham Spring, Methuen, Essex County.
Cadwell's Crystal Spring, Woburn, Middlesex County.
Cascella Springs, Three Rivers, Hampden County.
Chapman's Crystal Spring, Stoneham, Middlesex County.
Chelmsford Spring, Chelmsford, Middlesex County.
Chickatawbut Spring, Hingham, Plymouth County.
Cochato Spring, South Braintree, Norfolk County.
Crystal Spring, West Peabody, Essex County.
Deep Glen Spring, West Lynn, Essex County.
El-Azhar Spring, Tyngsboro, Middlesex County.
Goulding Spring, Whitman, Plymouth County.
Granite Rock Spring, Brockton, Plymouth County.
Great Radium Springs, Pittsfield, Berkshire County.
Holyoke Spring, West Lynn, Essex County.
Indian Spring, Brockton, Plymouth County.

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King Philip Spring, Mattapoisett, Plymouth County.
Klines Spring, Lawrence, Essex County.
Massasoit Spring, West Springfield, Hampden County.
Milton Spring, Milton, Norfolk County.
Mount Blue Mineral Spring, Hingham, Plymouth County.
Mount Holyoke Spring, South Hadley, Hampshire County.
Mount Pleasant Spring, Lowell, Middlesex County.
Mount Vernon Spring, Lawrence, Essex County.
New Abbott Spring, Methuen, Essex County.
Nobscot Mountain Spring, Framingham, Middlesex County.
Norwood Spring, Norwood, Norfolk County.
October Spring, Lenox, Berkshire County.
Pearl Hill Spring, Fitchburg, Worcester County.
Pepperell Spring, Pepperell, Middlesex County.
Pequot Mineral Spring, North Natick, Middlesex County.
Pocahontas Spring, Lynnfield Center, Essex County.
Polar Spring, Spencer, Worcester County.
Puritan Spring, Andover, Essex County.
Purity Spring, Danvers, Essex County.
Purity Spring, Chelmsford, Middlesex County.
Robbins Springs, Arlington Heights, Middlesex County.
Sand Springs, Williamstown, Berkshire County.
Shawmut Spring, West Quincy, Norfolk County.
Simpson Spring, South Easton, Bristol County.
Sippican Spring, Marion, Plymouth County.
Sterling Spring, West Lynn, Essex County.
Stevens Spring, Lawrence, Essex County.
Twin Elm Spring, Lexington, Middlesex County.
Valpey Spring, Lawrence, Essex County.
Whitman Spring, Whitman, Plymouth County.
Wilbraham Spring, Wilbraham, Hampden County.
Ye Cape Cod Pilgrim Spring, South Wellfleet, Barnstable County.

MICHIGAN.

The value of the mineral water sold in Michigan in 1916 was about 50 per cent greater than in 1915, as there was an increase from 8 to 11 cents in the average price per gallon. The total sales amounted to 996,875 gallons, as compared with 913,765 gallons in 1915, an increase of 9 per cent; and the total value was $108,867, as compared with $72,711 for 1915. The sale of table waters amounted to $101,658, and medicinal waters netted $7,209. Both of these figures represent substantial gains over 1915.

Production was reported from Deep Spring for the first time; 4 springs idle in 1915 were active in 1916; the output of 1 spring was estimated, and that of another was not reported. Three springs active in 1915 were reported idle in 1916; thus the number of active springs decreased from 19 to 18. Three resorts accommodating 1,600 guests and 1 mineral-water bathing establishment were maintained at springs. In addition to the mineral water sold about 25,478 gallons, as compared with 144,728 gallons in 1915, was used in the manufacture of soft drinks.

Mineral waters sold in Michigan, 1912–1916.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1912	18	1,420,465	$75,611	5
1913	20	884,893	52,642	6
1914	22	931,343	70,310	8
1915	19	913,765	72,711	8
1916	18	996,875	108,867	11

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The 18 springs reporting sales are as follows:

Americanus Spring, Lansing, Ingham County.
Andrews Magnetic Mineral Spring, St. Louis, Gratiot County.
Arctic Spring, Grand Rapids, Kent County.
Bailey Marvel Spring, between Bellaire and Alden, Antrim County.
Beaver Spring, Bangor, Van Buren County.
Bromo-Hygeia Well, Coldwater, Branch County.
Crystal Springs, Grand Rapids, Kent County.
Deep Spring, Wayne County.
Eastman Springs, near Benton Harbor, Berrien County.
Maple Leaf Springs, Macomb County.
Ogemaw Spring, Maltby, Ogemaw County.
Osseo Mineral Well, Osseo, Hillsdale County.
Panacea Spring, Mount Clemens, Macomb County.
Ponce de Leon Spring, Paris Township, Kent County.
Silver Springs, Northville, Wayne County.
Sterling Spring, Crystal Falls, Iron County.
Sultana Mineral Spring, near Hartford, Van Buren County.
Victory Spring, Mount Clemens, Macomb County.

MINNESOTA.

According to reports received from 18 active springs in Minnesota, the sales of mineral waters in that State increased 20 per cent in quantity and 7 per cent in value in 1916. The total output was 4,188,434 gallons, valued at $145,582. The sales of table water increased from $135,062 in 1915 to $145,027 in 1916, but the sales of medicinal waters declined from $1,197 in 1915 to $555 in 1916. The average price per gallon dropped from 4 to 3 cents. All of the springs that were active in 1915 reported sales in 1916, and one spring idle in 1915 was active in 1916. One resort for guests and one mineral-water bathing establishment were operated at springs. In addition to the quantity reported as sold, 506,738 gallons were used in the manufacture of soft drinks, which is a considerable increase over the quantity used in that industry in 1915.

Mineral waters sold in Minnesota, 1912–1916.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1912	18	8,881,018	$252,277	3
1913	16	4,802,053	183,759	4
1914	15	5,639,232	194,041	3
1915	17	3,493,887	136,259	4
1916	18	4,188,434	145,582	3

The 18 springs for which production was reported are as follows:

Campbells Spring, Fergus Falls, Ottertail County.
Clear Spring, Excelsior, Hennepin County.
Deep Spring, Crookston, Polk County.
Glenwood-Inglewood Spring, Minneapolis, Hennepin County.
Highland Spring, St. Paul, Ramsey County.
Indian Medical Spring, Elk River, Sherburne County.
Jackson Mineral Spring, Jackson, Jackson County.
Mankato Mineral Springs, near Eagle Lake, Blue Earth County.
Ogahmah Spring, Thief River Falls, Pennington County.
Owens Spring, Glenwood, Pope County.
Pokegama Spring, near Detroit, Becker County.

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Red Star Spring, Cold Spring, Stearns County.
Rock Spring, Shakopee, Scott County.
Rosendale Spring, St. James, Watonwan County.
Silver Well, Marshall, Lyon County.
Silver Spring, Ortonville, Bigstone County.
Trio Siloam Spring, Austin, Mower County.
Ward Springs, Ward Springs, Todd County.

MISSISSIPPI.

The mineral-water business in Mississippi, which showed a notable decrease in 1915, increased 54 per cent in quantity and 6 per cent in value in 1916, the sales reported being 399,248 gallons, practically all classed as medicinal water, valued at $48,439, as compared with 259,370 gallons, valued at $45,639, in 1915. The price per gallon decreased from 18 to 12 cents. Three springs temporarily idle in 1915 were producing in 1916, and 2 springs active in 1915 reported no sales in 1916. No new springs were reported to be active. Three mineral-water bathing establishments and 7 resorts, accommodating about 1,500 guests, were maintained at springs.

The names of the 12 springs reported active in 1916 follow:

Allison's Wells, Way, Madison County.
Brown's Wells, near Hazlehurst, Copiah County.
Castalian Springs, near Durant, Holmes County.
Cooper's Well, Raymond, Hinds County.
Donald Mineral Spring, Vosburg, Jasper County.
Lowes Wells, near Hazlehurst, Copiah County.
Milton's Well, near Raymond, Hinds County.
Morris Mineral Spring, Vosburg, Jasper County.
Owens Well, Owens, Holmes County.
Red Springs, Stewart, Choctaw County.
Robinson Spring, Madison County, near Pocahontas.
Stafford Mineral Spring, Vosburg, Jasper County.

MISSOURI.

The marked increase in production of mineral water in Missouri in 1915 continued through 1916, the increase being 39 per cent in quantity, as compared with 72 per cent in 1915, and 32 per cent in value, as compared with 12 per cent in 1915. The total output for 1916 was 1,394,092 gallons, valued at $109,814. There was considerable increase in the sales of medicinal waters, and the sales of table water almost exactly doubled. The average price per gallon remained 8 cents. In addition to the quantity reported as sold 31,262 gallons were used in the manufacture of soft drinks, a small decrease from the quantity reported for 1915. Reports for 1916 were received from 36 active springs, as compared with 33 in 1915. One well active in 1915 was reported closed, and 1 spring reported no sales. Eight springs temporarily idle in 1915 reported sales. Bowling Green B. B. Springs is now combined and reported with Fonzo Springs under the name B. B. and Fonzo Springs. Paris Springs is now called Chalybeate Springs. Six resorts, exclusive of those at Excelsior Springs, and 3 mineral-water bathing establishments were operated. A small quantity of mineral water also was used in the manufacture of soft drinks.

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Mineral waters sold in Missouri, 1912–1916.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1912	30	608,385	$81,114	13
1913	34	697,467	84,316	12
1914	36	553,288	74,793	13
1915	33	1,000,961	83,363	8
1916	37	1,304,092	109,814	8

The following 36 springs made returns of sales:

B. B. and Fonzo springs, Bowling Green, Pike County.
Belcher Artesian Well, St. Louis, St. Louis City County.
Blue Lick Springs, Blue Lick, Saline County.
Bokert Springs, near De Soto, Jefferson County.
Chalybeate Spring, Paris Springs, Lawrence County.
Chouteau Springs, near Boonville, Cooper County.
Crystal Mineral Spring, Excelsior Springs, Clay County.
Cusenbary Spring, Mount Washington, Jackson County.
Excelsior Saline Spring, Excelsior Springs, Clay County.
Grand River Mineral Spring, near Mercer, Mercer County.
Haymaker Spring, Mercer County, near Lineville, Iowa.
Hornet Spring, Bowling Green, Pike County.
Jackson Lithia Spring, Mount Washington, Jackson County.
Kalinat and Ionian springs, Bowling Green, Pike County.
Lithia No. 1 Spring, Excelsior Springs, Clay County.
McAllister Springs, near Houstonia, Saline County.
Musick Mineral Well, Eldorado Springs, Cedar County.
Natrona Wells, Excelsior Springs, Clay County.
Old Orchard Mineral Spring, Old Orchard, St. Louis County.
Paris Springs, Lawrence County.
Park Springs, Eldorado Springs, Cedar County.
Ponce de Leon Well, La Grange, Lewis County.
Regent, Siloam, Soterian, and Sulpho-Saline springs, Excelsior Springs, Clay County.
Salax Spring, Excelsior Springs, Clay County.
Salt Sulphur Well, Excelsior Springs, Clay County.
Soda Saline Spring, Missouri City, Clay County.
Sweet Spring, Sweet Springs, Saline County.
Vaile Spring, Independence, Jackson County.
White Spring, Independence, Jackson County.
Windsor Spring, Windsor Springs, St. Louis County.
Wyaconda and La Grange springs, La Grange, Lewis County.

MONTANA.

The production of 4 springs reporting from Montana for 1916 was 181,800 gallons, valued at $12,294. This represents a gain in quantity in 1916 of 59 per cent and in value of 86 per cent. Alhambra Hot Spring, in Jefferson County, reported for the first time. Mineral-water bathing establishments were maintained at 2 of these springs, and 1 resort accommodating 50 guests was reported. Practically all the water was sold for table use.

The 4 active springs are as follows:

Alhambra Hot Spring, Jefferson County.
Lissner Mineral Spring, Helena, Lewis and Clark County.
Rock Creek Springs, Red Lodge, Carbon County.
White Sulphur Springs, White Sulphur Springs, Meagher County.

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NEBRASKA.

The total production of 3 springs in Nebraska was reported for 1916 to be 8,440 gallons, as compared with 8,770 gallons from the same 3 springs in 1915. The total value of water sold was $946, the average price being 11 cents a gallon—the same as reported the previous year. One mineral-water bathing establishment and 1 resort for guests were maintained; and, in addition to the mineral water reported sold, about 205,600 gallons was used in the manufacture of soft drinks, as compared with 70,450 gallons used for this purpose in 1915.

The names of the 3 springs reporting are as follows:

Brown Park Mineral Springs, South Omaha, Douglas County.
Curo Mineral Spring, South Omaha, Douglas County.
Shogo Lithia Spring, Milford, Seward County.

NEVADA.

Three springs in Nevada active in 1915 reported sales in 1916 amounting to 346,260 gallons, valued at $4,160—a gain of 14 per cent in the quantity and a decrease of 3 per cent in the value of the total output. The average price was approximately 1 cent per gallon each year. Almost the entire output was classified as table water. A small quantity of mineral water, 764 gallons, was used in the manufacture of soft drinks.

The name of Ruby Mineral Spring has been changed to Secret Mineral Springs. No resorts or mineral-water bathing establishments were reported.

Reports were received from the following 3 springs:

Diamond Spring, Reno, Washoe County.
Secret Mineral Springs, Halleck, Elko County.
Shoshone Springs, Franktown, Washoe County.

NEW HAMPSHIRE.

Returns from New Hampshire indicate a substantial increase both in quantity and in value of mineral water marketed in 1916. The total sales in 1916 were 269,860 gallons, as compared with 176,385 gallons in 1915 and the total value of the output was $14,935, as compared with $6,737 in 1915. Almost all of the output was classified as table water. The average price per gallon, which dropped from 6 to 4 cents in 1915, was again 6 cents in 1916. One spring that was active in 1915 reported no sales in 1916. No new springs were reported. In addition to the mineral water sold, 313,881 gallons were used in the manufacture of soft drinks as compared with 118,250 gallons used in that industry in 1915.

The 6 springs reporting are as follows:

Crystal Spring, East Concord, Merrimack County.
Granite State Spring, Plaistow, Rockingham County.
Laconia Spring, The Weirs, Belknap County.
Lafayette Mineral Spring, Derry, Rockingham County.
White Mountain Mineral Spring, Conway, Carroll County.
Wilton Mineral Spring, near Wilton, Hillsboro County.

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NEW JERSEY.

The mineral-water business in New Jersey increased in quantity from 1,479,479 gallons in 1915 to 1,580,028 gallons in 1916, a gain of nearly 7 per cent, and in value of output from $116,226 to $130,993, a gain of about 13 per cent. The average price per gallon remained at 8 cents. Most of the output was classified as table water. In addition to the water reported as sold, 91,000 gallons was used in the manufacture of soft drinks, as compared with 26,657 gallons used in that business in 1915.

No new springs were reported; 3 springs idle in 1915 reported sales in 1916, and 1 spring which reported sales in 1915 failed to report for 1916; thus the number of active springs increased from 13 to 15. No resorts or mineral-water baths were maintained.

Mineral waters sold in New Jersey, 1912–1916.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1912	12	2,386,217	$209,726	9
1913	14	2,067,277	188,546	9
1914	17	1,710,030	155,649	9
1915	13	1,479,479	116,226	8
1916	15	1,580,028	130,993	8

The following 15 springs reported sales:

Alpha Spring, Springfield, Union County.
Belmar Springs, Glen Rock, Bergen County.
Cold Indian Spring, near Asbury Park, Monmouth County.
Culm Rock Spring, Pluckemin, Somerset County.
Echo Spring, Ewing (near Trenton), Mercer County.
Grey Rock Artesian Well, Trenton, Mercer County.
Indian Spring, near Rockaway, Morris County.
Indian Lady Hill Springs, Asbury Park, Monmouth County.
Kalium Spring, Collingswood, Camden County.
Kanouse-Oakland Spring, Oakland, Bergen County.
Pilgrim Spring, Ridgefield Park, Bergen County.
Red Rock Spring, Spring Valley Road, Bergen County.
Rock Spring, West Orange, Essex County.
Washington Rock Spring, Somerset County, near Plainfield.
Watchung Spring, North Plainfield, Somerset County.

NEW MEXICO.

The sales of mineral waters from 4 springs in New Mexico during 1916 was 35,450 gallons, valued at $3,965, as compared with 42,400 gallons, valued at $6,680, in 1915, a decrease of 16 per cent in quantity and 41 per cent in value. The disproportion between the loss in quantity and in value is accounted for by a decline from 16 to 11 cents in the average price per gallon. Practically all this water is reported to have been sold for table use. One small resort and 1 mineral-water bathing establishment were maintained. In addition to the water sold, 11,000 gallons was used in the manufacture of soft drinks. One spring which marketed water in 1915 reported no sales for 1916, and 1 spring not reported in 1915 was active in 1916.

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The 4 springs for which production was reported are as follows:

Aztec Mineral Springs, Taylor Springs, Colfax County.
Coyote Spring, Albuquerque, Bernalillo County.
Macbeth Spring, near East Las Vegas, San Miguel County.
Ojo Caliente Spring, Ojo Caliente, Taos County.

NEW YORK.

The State of New York in 1916 ranked first in number of active mineral springs and in total quantity of mineral waters, second in total value of production and in value of table waters, sixth in value of medicinal waters, and thirteenth in consumption of mineral waters for the manufacture of soft drinks. Comparison of figures for 1916 with those of 1915 shows a decrease of 8 per cent in quantity and of 2 per cent in value in 1916. The additional quantity used in the manufacture of soft drinks in 1916 was 182,907 gallons.

No new springs reported. In 1916 there were 68 active springs, as against 75 in 1915. The name Crystal has been changed to Crystaldale, and the Saratoga Gurn is now named Gurn. The springs formerly called collectively the Saratoga Reservation Springs are now named the Conservation Commission Springs. The names of two have been changed. Orenda is now Congress No. 2, and the Saratoga Soft Sweet has been renamed Ferndell. Nearly nine-tenths of the water is sold for table use. Four resorts exclusive of those at Saratoga Springs accommodated 5,500 guests, and mineral-water bathing establishments were operated at 4 springs in 1916.

Mineral waters sold in New York, 1912–1916.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1912	57	10,008,801	$1,034,477	10
1913	64	9,801,255	871,801	9
1914	69	8,201,202	672,913	8
1915	75	8,411,616	711,697	8
1916	68	7,746,490	697,650	9

The list of 68 commercial springs in 1916 is as follows:

Arlington Spring, Arlington, Dutchess County.
Arrowhead Spring, Weedsport, Cayuga County.
Artesian Lithia Spring, Ballston Spa, Saratoga County.
Baldwin Mineral Spring, Cayuga, Cayuga County.
Black Rock Spring, Rensselaer, Rensselaer County.
Breesport Oxygenated Mineral Spring, Breesport, Chemung County.
Briarcliff Spring, Briarcliff Manor, Westchester County.
Carrier Spring, Potsdam, St. Lawrence County.
Cascadian Spring, Nyack, Rockland County.
Cassadaga Spring, Stockton, Chautauqua County.
Chemung Spring, Chemung, Chemung County.
Clinton Mineral Springs, Franklin Springs, Oneida County.
Coesa Spring, Saratoga Springs, Saratoga County.
Comstock Mineral Spring, Ballston Spa, Saratoga County.
Congress No. 2 Spring, Saratoga Springs, Saratoga County.
Crystaldale Spring, Crystal Dale, Lewis County.
Crystal Springs, near Oswego, Oswego County.

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Deep Rock Spring, Oswego, Oswego County.
Dietade Mineral Spring, Keeseville, Essex County.
Eagle Spring, Edgewood, Greene County.
Elixir Spring, Clintondale, Ulster County.
Elk Spring, Lancaster, Erie County.
Ferndell Spring, Saratoga Springs, Saratoga County.
Flint Spring, near West Sand Lake, Rensselaer County.
Franklin Lithia Spring, Kirkland, Oneida County.
Gardner White Sulphur Springs, Sharon Springs, Schoharie County.
Geneva Mineral Spring, Geneva, Ontario County.
Geyser Spring, Saratoga Springs, Saratoga County.
Glen Alex Spring, New Hartford, Oneida County.
Gramatan Spring, Bronxville, Westchester County.
Granite Spring, Granite Springs, Westchester County.
Great Bear Spring, near Fulton, Oswego County.
Great White Sulphur Spring, Richfield Springs, Otsego County.
Greendale Crystal Springs, Livingston, Columbia County.
Gurn Spring, Saratoga Springs, Saratoga County.
Hathorn No. 1 Spring, Saratoga Springs, Saratoga County.
Hathorn No. 2 Spring, Saratoga Springs, Saratoga County.
Kirkland Spring, Kirkland, Oneida County.
Lithia Polaris Spring, near Boonville, Oneida County.
Madrid Medicinal and Indian Mineral Springs, Madrid Springs, St. Lawrence County.
Mammoth and Ideal springs, North Greenbush, Rensselaer County.
Massena Springs, Massena, St. Lawrence County.
Minnonebe Spring, Saratoga Springs, Saratoga County.
Mohawk Springs, Amsterdam, Montgomery County.
Mohican Spring, Ballston Spa, Saratoga County.
Mokobo Spring, Mount Kisco, Westchester County.
Monarch Spring, Mattewan, Dutchess County.
Paris Spring, Sanquoit, Oneida County.
Plymouth Spring, North Greenbush, Rensselaer County.
Red Rock Spring, Fine View, Jefferson County.
Risley Cold Springs, New York Mills, Oneida County.
Sagamore Spring, Oyster Bay, Nassau County.
Saratoga Vichy and Victoria No. 2 springs, Saratoga Springs, Saratoga County.
Setauket Spring, Setauket, Suffolk County.
Shell Rock Spring, near Rensselaer, Rensselaer County.
Shenorock Spring, Baldwin Place, Westchester County.
Sparkling Spring, Buffalo, Erie County.
Split Rock Lithia Spring, Franklin Springs, Oneida County.
Standard Spring, Troy, Rensselaer County.
Sun Ray Spring, Ellenville, Ulster County.
Table Rock Mineral Spring, Honeoye Falls, Monroe County.
Trespur Spring, McGraw, Cortland County.
Vita Spring, near Fort Edward, Washington County.
Westmoreland Mineral Spring, Westmoreland, Oneida County.
White Bear Spring, Batavia, Genesee County.
White's Spring, Norwich, Chenango County.

NORTH CAROLINA.

The mineral-water business in North Carolina remained practically the same in 1916 as in 1915 and the average price per gallon remained the same—14 cents. The sales amounted to 137,817 gallons, valued at $19,010, as compared with 132,813 gallons, valued at $18,745, in 1915. No mineral water was consumed in the manufacture of soft drinks. Twelve resorts, accommodating about 1,700 guests, and three establishments for bathing in mineral water were maintained at springs. Derita Mineral Spring is now known as Derita Calcic Spring.

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The 19 springs that reported production are as follows:

All Healing Spring, Taylorsville, Alexander County.
Barium Rock Spring, Barium Springs, Iredell County.
Bromine Arsenic Lithia Springs, Crumpler, Ashe County.
Buckhorn Lithia Spring, Bullock, Granville County.
Connelly Mineral Spring, Connelly Springs, Burke County.
Derita Calcic Spring, Derita, Mecklenburg County.
Haywood White Sulphur Springs, Waynesville, Haywood County.
Huckleberry Springs, Durham, Durham County.
Jackson Springs, Jackson Springs, Moore County.
Mida Spring, near Huntersville, Mecklenberg County.
Moores Springs, Moores Springs, Stokes County.
Mount Vernon Springs, Mount Vernon Springs, Chatham County.
Panacea Springs, Warren County, near Littleton.
Parks Spring, Caswell County, near Danville, Va.
Seven Springs, Sevensprings, Wayne County.
Shelby Lithia Springs, near Shelby, Cleveland County.
Sherrill Mineral Springs, near Cabarrus, Cabarrus County.
Smith Lithia Springs, near Oxford, Granville County.
Vade Mecum Spring, Vade Mecum, Stokes County.

NORTH DAKOTA.

Reports of sales were received from six active springs in North Dakota—three more than reported in 1915—which showed an increase in sales of 61 per cent in quantity and 66 per cent in value. The total output was 766,000 gallons, valued at $14,500, as compared with 475,000 gallons, valued at $8,750, in 1915. The sale of table water amounted to $13,750, and $750 was received from the sale of medicinal water, the same as in 1915. Thus the increase in the total output is due entirely to growth of trade in table water. In addition to the quantity reported as sold, 34,722 gallons was used for soft drinks, a very considerable decrease below the quantity used in 1915, when a consumption of 250,000 gallons was reported. Three springs which were idle in 1915 reported sales.

The names and locations of the six springs reporting production are as follows:

Gordon Springs, Michigan, Nelson County.
Granite Spring, Minot, Ward County.
Kenmare Spring, Kenmare, Ward County.
Sakakawea Spring, Northwood, Grand Forks County.
Stony Creek Spring, Bowbells, Burke County.
Williston Medicinal Spring, Williston, Williams County.

OHIO.

Returns from Ohio for 1916 show an increase in the sales of mineral water of 17 per cent in quantity and 21 per cent in value, due to increased sales of medicinal water. The total output was 4,102,922 gallons, valued at $161,160, as compared with 3,504,343 gallons, valued at $133,416, in 1915. The average price per gallon has been 4 cents for the last seven years. The mineral water used in the manufacture of soft drinks increased from 21,000 to 168,200 gallons.

Two new springs, Crystal Wave and Gibson, were added to the list of producers. The total number of active springs in 1916 was 37. Six resorts, accommodating about 750 guests, and three mineral-water bathing establishments were maintained.

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Mineral waters sold in Ohio, 1912–1916.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1912	30	2,709,745	$117,287	4
1913	33	3,317,639	125,084	4
1914	35	3,558,413	145,586	4
1915	36	3,504,343	133,416	4
1916	37	4,102,922	161,160	4

The 37 springs reporting sales are as follows:

Alba Springs, Rockport, Cuyahoga County.
Beech Rock Spring, near Zanesville, Muskingum County.
Bellmore Spring, near Signal, Columbiana County.
Belmont Spring, Bridgeport, Belmont County.
Collingwood Springs, Toledo, Lucas County.
Crum Mineral Spring, Austintown, Mahoning County.
Crystal Springs, Newark, Licking County.
Crystal Fountain Springs, Plainville, Hamilton County.
Crystal Wave Springs, Youngstown, Mahoning County.
Deerfield Mineral Springs, Deerfield, Portage County.
Devonian Mineral Spring, Lorain, Lorain County.
Elm Meade Spring, Youngstown, Trumbull County.
Fargo Mineral Springs, Ashtabula, Ashtabula County.
Fisher's Magnesia Spring, near Columbus, Franklin County.
Gibson Spring, Youngstown, Mahoning County.
Glenwood Mineral Spring, near Chillicothe, Ross County.
Highland Springs, Akron, Summit County.
La France Spring, Toledo, Lucas County.
Maple Grove Mineral Spring, near Chillicothe, Ross County.
Minnehaha Spring, Rockport, Cuyahoga County.
Navahoe Springs, near New Paris, Preble County.
Oak Place Spring, Akron, Summit County.
Oak Ridge Mineral Springs, Sandusky County, near Greenspring.
Old Magnetic Spring, Magnetic Springs, Union County.
Painesville Mineral Spring, Painesville, Lake County.
Partagas Natural Well, Cincinnati, Hamilton County.
Peerless and Puritas springs, West Park, Cuyahoga County.
Pine Tree Spring, Willoughby, Lake County.
Puritas Spring, near Berea, Cuyahoga County.
Purity Spring, South Euclid, Cuyahoga County.
Quakerdale Spring, Colerain, Belmont County.
Ripley Bromo Lithia Spring, Ripley, Brown County.
Rock Spring, Wickliffe, Lake County.
Sand Rock Mineral Spring, Canton, Stark County.
Sulphur Lick Springs, Chillicothe, Ross County.
Tallewanda Springs, Preble County, near College Corner.
Wheeler Springs, Youngstown, Mahoning County.

OKLAHOMA.

The output of mineral water in Oklahoma in 1916 was 1,353,513 gallons, valued at $40,189, as compared with 890,392 gallons, valued at $24,005, in 1915. These figures correspond to an increase of 52 per cent in quantity and 67 per cent in value. In addition to the quantity sold, 35,163 gallons of mineral water was consumed in the manufacture of soft drinks. White Sulphur Spring was formerly called Sulphur Spring. One spring active in 1915 was not reported in 1916 and was considered idle, and 1 idle in 1915 was active in 1916; thus

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the total number of springs active in 1916 was 13. One resort and 1 mineral-water bathing establishment were maintained.

The 13 springs reporting sales are as follows:

Bromide Spring, Sulphur, Murray County.
Comanche Mineral Wells, Comanche, Stephens County.
Everpure Well, Oklahoma City, Oklahoma County.
Excelsior Well, Oklahoma City, Oklahoma County.
Guthrie Mineral Springs, Guthrie, Logan County.
Kalium Well, Faxon, Comanche County.
Lewis Lithia Wells, Oklahoma City, Oklahoma County.
Living Spring, Oklahoma City, Oklahoma County.
Shanoan Springs, Chickasha, Grady County.
Sparkling Water Well, near Shawnee, Pottawatomie County.
Standard Wells, Tulsa, Tulsa County.
White Sulphur Spring, Sapulpa, Creek County.
Works Excelsior Mineral Wells, Comanche, Stephens County.

OREGON.

Returns for 1916 show practically no change in the mineral-water business in Oregon. The production was 30,920 gallons, valued at $7,961, as compared with 28,747 gallons, valued at $8,729, in 1915. The average price per gallon dropped from 30 to 26 cents. One spring active in 1915 reported no sales in 1916; thus the number of active springs was reduced from 7 to 6. Five resorts accommodating about 340 guests and 5 mineral-water bathing establishments were maintained. In addition to the water reported sold 16,544 gallons was used in manufacturing soft drinks. White Pelican Mineral Spring was formerly called Klamath Spring.

The names of the 6 springs reporting production are as follows:

Calapooya Spring, London, Lane County.
Cascade Mineral Springs, Cascadia, Linn County.
Colestin Spring, Colestin, Jackson County.
Sam-O-Spring, Baker, Baker County.
White Pelican Mineral Spring, Klamath Falls, Klamath County.
Wilhoit Spring, Wilhoit, Clackamas County.

PENNSYLVANIA.

The returns from Pennsylvania indicate a decrease of 22 per cent in quantity and 17 per cent in value of mineral water sold in 1916, as compared with reports for 1915, and the price per gallon increased from 8 to 9 cents. The total output was 1,671,637 gallons, valued at $145,133. The sales of table water amounted to $123,235, and $21,898 was reported from sales of medicinal water. In addition 337,635 gallons was used in the manufacture of soft drinks, which is a considerable increase as compared with 1915.

Forty-two springs were active in 1916, of which 2 had been idle in 1915, and 7 springs which marketed water in 1915 were inactive in 1916. Beford Magnesia Springs are now called Bedford Springs. The sales from 1 unreported spring have been estimated. Eight resorts accommodating 1,000 guests and 2 mineral-water bathing establishments were maintained.

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Mineral waters sold in Pennsylvania, 1912–1916.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1912	41	2,192,106	$204,906	9
1913	43	2,168,931	190,459	9
1914	47	2,457,626	213,752	9
1915	47	2,136,218	174,796	8
1916	42	1,671,637	145,133	9

The following 42 springs reported sales in 1916:

Battering Ram Spring, Beach Haven, Luzerne County.
Bedford Springs, near Bedford, Bedford County.
Carnegie Alkaline and Lithia Mineral Springs, Carnegie, Allegheny County.
Chadwick Mineral Well, Cambridge Springs, Crawford County.
Cloverdale Mineral Spring, near Newville, Cumberland County.
Cold Spring, Lotell, Lebanon County.
Dark Hollow Spirng, near Oakmont, Allegheny County.
De Profundis Spring, Saegerstown, Crawford County.
Elkoro Spring, Girard, Erie County.
Ephrata Mountain Crystal Spring, near Ephrata, Lancaster County.
Fieldmore Springs, Titusville, Crawford County.
Franklin Lithia Spring, Cambridge Springs, Crawford County.
Glen Crystal Spring, Harbor Creek, Erie County.
Glen Summit Spring, Glen Summit, Luzerne County.
Great Oak Spring, Pottstown, Chester County.
Harrison Valley Mineral Spring, Harrison Valley, Potter County.
Hi-Rox Springs, near Lanesboro, Susquehanna County.
Hurlburt Springs, Cambridge Springs, Crawford County.
Hutchinson's Spring, New Castle, Lawrence County.
Jeny-See Spring, Genesee, Potter County.
Juniata Springs, near Altoona, Blair County.
Kecksburg Artesian Mineral Springs, Kecksburg, Westmoreland County.
Keystone Spring, near Taylorsville, Bucks County.
Minnequa Spring, Canton, Bradford County.
Mount Laurel Springs, Temple, Berks County.
No. 1 Mineral Spring, Mount Jewett, McKean County.
Original Magnesia Springs, Cambridge Springs, Crawford County.
Petticord Spring, Cambridge Springs, Crawford County.
Plymouth Crystal Spring, Plymouth, Luzerne County.
Polar Spring, Morrisville, Bucks County.
Puritas Spring, near Erie, Erie County.
Quaill Farm Spring, Bellevue, Allegheny County.
Ross Common Spring, Ross Common, Monroe County.
Sizerville Magnetic Mineral Spring, Sizerville, Cameron County.
Springfield Spring, Springfield Township, Delaware County.
Summer Hill Spring, Pittsburgh, Allegheny County.
Thurstons Carbonate Springs, Meadville, Crawford County.
Tuckahoe Mineral Springs, near Northumberland, Northumberland County.
West Nanticoke Artesian Well, West Nanticoke, Luzerne County.
Whannis Lithia Springs, Franklin, Venango County.
White House Spring, Reading, Berks County.
White Star Spring, Northampton County.

RHODE ISLAND.

Rhode Island reported in 1916 sales from six springs amounting to 449,453 gallons, valued at $33,050. The average price per gallon rose from 6 to 7 cents. The water was sold exclusively for table use, and in addition 16,500 gallons was used in the manufacture of soft

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drinks. The sales in 1915 amounted to 385,624 gallons, valued at $24,574, or at 6 cents a gallon. Thus there was an increase of 17 per cent in quantity and 35 per cent in value. One mineral-water resort was maintained.

The names of the 6 commercial springs are as follows:

Berry Spring, Pawtucket, Providence County.
Girard Spring, North Providence, Providence County.
Gladstone Spring, Narragansett Pier, Washington County.
Holley Mineral Spring, East Woonsocket, Providence County.
Ochee Spring, Johnston, Providence County.
Prophet Spring, Providence, Providence County.

SOUTH CAROLINA.

The sales of mineral water in South Carolina during 1916 amounted to 427,905 gallons, valued at $63,818, as compared with 480,051 gallons, valued at $67,869, in 1915. These small changes are equivalent to decreases of 11 per cent in quantity and 6 per cent in value. Ninety-two per cent of the output is said to be sold for medicinal use. One spring idle in 1915 was active in 1916, 3 springs active in 1915 were idle in 1916, and the output of 1 spring unreported in 1916 was estimated. Thus the number of active springs was reduced to 10. Mansfield Mineral Springs was added to the list of producers. Three resorts accommodating 800 guests were maintained. In addition to the mineral water reported sold, 303,150 gallons was used in manufacturing soft drinks.

The following 10 springs reported sales:

Antley Springs, St. Matthews, Calhoun County.
Buffalo Lick Spring, Carlisle, Union County.
Chick Springs, Chick Springs, Greenville County.
Clementia Mineral Spring, Clementia, Colleton County.
Glendale Mineral Spring, Bamberg, Bamberg County.
Glenn Springs, Glenn Springs, Spartanburg County.
Harris Springs, Harris Springs, Laurens County.
Mansfield Mineral Springs, near Spartanburg, Spartanburg County.
Shivar Spring, Shelton, Fairfield County.
White Diamond Lithia Springs, near Kings Creek, York County.

SOUTH DAKOTA.

Five springs in South Dakota reported sales in 1916, 2 of which, Milbank Well and Spring Brook, are new on the list. The sales amounted to 470,725 gallons, valued at $20,512, as compared with 176,000 gallons, valued at $9,360, in 1915, an increase of 168 per cent in quantity and 119 per cent in value. The average price per gallon dropped from 5 to 4 cents. All but 52 gallons of this water was sold for table use, and 59,868 gallons in addition was used in manufacturing soft drinks. No resorts or bathing establishments were maintained.

The names of the 5 springs reporting are as follows:

Culbert Spring, Aberdeen, Brown County.
Kampeskee Spring, Watertown, Codington County.
Milbank Well, Milbank, Grant County.
Minnehaha Springs, Sioux Falls, Minnehaha County.
Spring Brook Spring, Sisseton, Roberts County.

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TENNESSEE.

The mineral-water trade of Tennessee showed an increase of 14 per cent in quantity and 23 per cent in value. The chief increase was in sales of certain waters marketed for medicinal use. The average price per gallon has remained the same for the last four years.

The total output for 1916 was 799,346 gallons, valued at $48,416, as compared with 703,566 gallons, valued at $39,304, in 1915. The sales of medicinal waters amounted to $27,920 and table waters to $20,496.

Bright Sunrise Springs is now called Sunrise Springs, and Richardsons Lockeland Spring is now called Lockeland Spring. Ten resorts, accommodating about 1,500 guests, and 3 mineral-water bathing establishments were operated.

Mineral waters sold in Tennessee, 1912–1916.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1912	21	796,568	$53,560	7
1913	23	1,068,034	64,905	6
1914	23	943,502	56,741	6
1915	23	703,566	39,304	6
1916	20	799,346	48,416	6

The following 20 springs reported sales:

Bush Epsom Lithia Wells, Davidson County, near Nolensville.
Darnell Well, Clarksville, Montgomery County.
Eagle Bluff Springs, Jacksboro, Campbell County.
Eastbrook Springs, Eastbrook, Franklin County.
Faulkner Springs, near McMinnville, Warren County.
Galbraith Epsom Lithia Well, near Galbraith Springs, Hawkins County.
Horn Springs, Horn Springs, Wilson County.
Larkin Spring, Madison, Davidson County.
Lockeland Spring, near Nashville, Davidson County.
Montvale Springs, Maryville, Blount County.
Neubert Spring, near Neubert, Knox County.
Pioneer Lithia Spring, near Nashville, Davidson County.
Red Boiling Springs, Red Boiling Springs, Macon County.
Rhea Springs, Rhea Springs, Rhea County.
Sunrise Spring, near Ashland City, Cheatham County.
Tate Spring, Tate Springs, Grainger County.
Thompson Spring, near Nashville, Davidson County.
Whittle Springs, near Whittle Springs, Knox County.
Willow Brook Spring, Craggie Hope, Cheatham County.
Wright's Epsom-Lithia Spring, Mooresburg, Hawkins County.

TEXAS.

There was a decrease in the mineral-water business in Texas during 1916 of 16 per cent in quantity and 3 per cent in value, most of the water, as during 1915, having been reported as sold for medicinal use. The total sales amounted to 703,002 gallons, valued at $97,513. In addition, about 29,000 gallons of mineral water was consumed in manufacturing soft drinks.

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No new springs were reported. Three springs active in 1915 were reported idle in 1916, 4 idle in 1915 were active in 1916, and the output for 1916 of 1 spring was estimated. Lonestar Mineral Well is now called Texarkana Lone Star Mineral Wells. Six resorts, accommodating about 500 guests, and 5 mineral-water bathing establishments were reported.

Mineral waters sold in Texas, 1912–1916.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1912	34	1,202,992	$151,305	12
1913	38	1,187,612	132,458	11
1914	31	766,597	93,014	12
1915	29	835,142	100,090	12
1916	30	703,002	97,513	14

The following is the list of the 30 springs reporting sales during 1916:

Aqua Vitae Wells, Nacogdoches, Nacogdoches County.
Austin Well, Mineral Wells, Palo Pinto County.
Beauchamp's Well, Blossom, Lamar County.
Brocks Mineral Wells, near Denton, Denton County.
Capps Mineral Wells, Longview, Gregg County.
Crazy and Gibson Wells, Mineral Wells, Palo Pinto County.
Dalby Spring, Dalby Springs, Bowie County.
Georgetown Mineral Wells, Georgetown, Williamson County.
Hanna Springs, Lampasas, Lampasas County.
Hefner Well, Blossom, Lamar County.
Hubbard Hot Well, Hubbard, Hill County.
Lamar Wells, Mineral Wells, Palo Pinto County.
Mangum Wells, Mangum, Eastland County.
Maurice Wells, Mangum, Eastland County.
Mitchell Well, Greenville, Hunt County.
Olympia Well, Mineral Wells, Palo Pinto County.
Overall Mineral Wells, Franklin, Robertson County.
Riviere Mineral Wells, Tyler, Smith County.
Roach Mineral Well, near Mount Pleasant, Titus County.
Rock Bottom Well, Mineral Wells, Palo Pinto County.
Rosborough Spring, Marshall, Harrison County.
St. Mary's Mineral Well, near Hallettsville, Lavaca County.
Sour Well, Sulphur Springs, Hopkins County.
Southland Spring, Duffau, Erath County.
Texarkana Lonestar Mineral Wells, Texarkana, Bowie County.
Texas Carlsbad Wells, Mineral Wells, Palo Pinto County.
Tioga Mineral Wells, Tioga, Grayson County.
Weatherby Wells, Garrison, Nacogdoches County.
Wizard Wells, Wizard Wells, Jack County.
Wootan Wells, Wootan Wells, Robertson County.

UTAH.

One spring in Utah reported production in 1916, and statistics regarding it are included with those of other States having less than three operating springs.

The name and location of the spring reporting is:

Utahna Springs, Wasatch Mountains.

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VERMONT.

The mineral-water trade in Vermont in 1916 was 18 per cent greater in quantity and 7 per cent greater in value than in 1915. The production was 72,590 gallons, valued at $15,395, as compared with 61,540 gallons, valued at $14,382, in 1915. The average price per gallon dropped from 23 to 21 cents. In addition to this production about 30,000 gallons was used in making soft drinks. Three resorts, accommodating 650 guests, and 2 mineral-water bathing establishments were maintained.

Five springs were active, as follows:

Alburg Springs, Alburg Springs, Grand Isle County.
Clarendon Nitrogen and North springs, Clarendon Springs, Rutland County.
Cold Spring, Wells, Rutland County.
Equinox Spring, Manchester, Bennington County.

VIRGINIA.

Returns from Virginia show that in 1916 the mineral-water business in that State decreased 24 per cent in quantity and increased about 5 per cent in value, largely on account of an increase in the sales of medicinal water. The total output was 2,313,616 gallons, valued at $248,906, as compared with 3,027,528 gallons, valued at $237,818, in 1915. The average price rose from 8 to 11 cents per gallon. In addition to the water reported as sold 98,721 gallons was used in manufacturing soft drinks. Two springs idle in 1915 were active in 1916 and two springs active in 1915 were reported idle in 1916. Thus the number of active springs remained the same. Thirteen resorts, accommodating nearly 1,900 guests, and five mineral-water bathing establishments were maintained at springs.

Mineral waters sold in Virginia, 1912–1916.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1912	45	2,762,319	$349,255	13
1913	49	2,873,288	298,473	10
1914	50	2,906,976	293,512	10
1915	50	3,027,528	237,818	8
1916	50	2,313,616	248,906	11

The 50 springs reporting sales are as follows:

Albevanna Ponce de Leon Spring, Fluvanna County, near Scottsville.
Alkaline Lithia Spring, near Staunton, Augusta County.
Alleghany Spring, Alleghany Springs, Montgomery County.
Bear Lithia Spring, near Elkton, Rockingham County.
Beaufont Spring, Chesterfield County, near Richmond.
Berry Hill Mineral Spring, Elkwood, Culpeper County.
Blue Ridge Springs, near Blue Ridge Springs, Botetourt County.
Broad Rock Mineral Spring, Chesterfield County, near Richmond.
Brugh's Spring, Nace, Botetourt County.
Buckhead Springs, Buckhead Springs, Chesterfield County.
Buffalo Lithia Springs, Buffalo Lithia Springs, Mecklenburg County.
Burnett Spring, Culpeper, Culpeper County.
Carter Springs, Danville, Pittsylvania County.

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Chlorinated Calcic Spring, Norfolk, Norfolk County.
Como Spring, East Richmond, Henrico County.
Coppahaunk Mineral Spring, Waverly, Sussex County.
Coyners and Blue, White, and Black Springs, Bonsack, Botetourt County.
Crockett Arsenic Lithia Springs, Crockett Springs, Montgomery County.
Crystal Springs, near Hampton, Elizabeth City County.
Diamond Spring, near Norfolk, Princess Anne County.
Eaglewood Mineral Springs, near Danville, Pittsylvania County.
Farmville Lithia Springs, Cumberland County, near Farmville.
Fonticello Spring, Chesterfield County, near Richmond.
Granite Mineral Spring, Chesterfield County, near Richmond.
Harris Anti-Dyspeptic Spring, Burkeville, Nottoway County.
Healing Springs, Healing Springs, Bath County.
Jeffress Lithia Silica Spring, Jeffress, Mecklenburg County.
Kayser Lithia Springs, Staunton, Augusta County.
Landale Spring, Norfolk, Norfolk County.
Lithia Magnesia Springs, Rockymount, Franklin County.
Magee's Chlorinated Lithia Spring, Clarksville, Mecklenburg County.
Massanetta Spring, near Harrisonburg, Rockingham County.
Mecklenburg Mineral Springs, Chase City, Mecklenburg County.
Mico Well, Alexandria, Alexandria County.
Mulberry Island Lithia Well, Mulberry Island, Warwick County.
Nye Lithia Springs, Wytheville, Wythe County.
Otterburn Lithia Spring, Amelia C. H., Amelia County.
Paeonian Spring, Paeonian Springs, Loudoun County.
Pickett Spring, Worsham, Prince Edward County.
Rockbridge Alum Spring, Rockbridge Alum Springs, Rockbridge County.
Rubino Healing Springs, Healing Springs, Bath County.
Seawright Magnesian Lithia Spring, near Staunton, Augusta County.
Stribling Springs, near Mount Solon, Augusta County.
Trepho Mineral Spring, Claremont, Surry County.
Victoria Alka-Lithia Well, Victoria, Lunenburg County.
Virginia Etna Springs, Vinton, Roanoke County.
Virginia Lithia Spring, Chesterfield, Chesterfield County.
Virginia Magnesia Alkaline Springs, near Staunton, Augusta County.
Wallawhatoola Springs, Millboro, Bath County.
Wyrick Mineral Spring, near Crockett, Wythe County.

WASHINGTON.

Washington's output of mineral water in 1916 was 151,528 gallons, valued at $9,476, or at 6 cents a gallon, whereas the output in 1915 was 158,865 gallons, valued at $11,703, or at 7 cents a gallon. Thus there was a decrease of 5 per cent in quantity and 19 per cent in value. No new springs were reported. One spring active in 1915 was reported closed in 1916. Yakima Artesian Mineral Spring is now called Artesian Mineral Spring. One resort and one mineral-water bathing establishment were maintained, and about 96,000 gallons of mineral water was used in manufacturing soft drinks.

The names of the 4 active springs are:

Ahtanum Soda Springs, near Tampico, Yakima County.
Artesian Mineral Spring, North Yakima, Yakima County.
Diamond Natural Mineral Spring, Auburn, King County.
Klickitat Mineral Spring, Klickitat, Klickitat County.

WEST VIRGINIA.

The output of mineral water in West Virginia in 1916 amounted to 287,466 gallons, valued at $46,686, as compared with 314,909 gallons, valued at $50,271, in 1915. This change is equivalent to a decrease of 9 per cent in quantity and 7 per cent in value. Two springs active in

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1915 were idle in 1916. Nine springs were active, the same number as in 1915. Five resorts, accommodating about 1,500 guests, and 4 mineral-water bathing establishments, were operated at springs.

The following are the names of the 9 commercial springs reporting in 1916:

Borland Mineral Springs, Borland, Pleasants County.
Madeira Well, Morgantown, Monongalia County.
Manacea Irondale Spring, Independence, Preston County.
Pence Spring, Pence Springs, Summers County.
Saline Chalybeate and Vigora Springs, Woodsdale, Ohio County.
Walnut Hill Spring, near Charleston, Kanawha County.
Webster Springs Salt Sulphur Water, Webster Springs, Webster County.
White Sulphur Springs, White Sulphur Springs, Greenbrier County.

WISCONSIN.

A pronounced increase in the sales of mineral waters in Wisconsin is indicated by the reports for 1916. The total output was 7,696,813 gallons, valued at $1,507,679, as compared with 4,861,734 gallons, valued at $1,051,405, in 1915. These figures represent an increase of 58 per cent in quantity and 43 per cent in value. The sales of table water amounted to $1,430,700 and of medicinal waters to $76,979. The average price per gallon dropped from 22 to 20 cents. In addition to the water reported as sold, 1,500,917 gallons was used in making soft drinks. One resort, accommodating 1,700 guests, and 1 mineral-water bathing establishment were operated at springs. Two springs temporarily idle in 1915 were productive in 1916, thus the total number of springs reporting production was 36, and 2 which reported sales in 1915 were idle in 1916. High Rock Spring reported for the first time. Waukesha Roxo Spring is now called Roxo Spring.

Mineral waters sold in Wisconsin, 1912–1916.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1912	31	6,045,719	$869,495	14
1913	34	6,326,533	872,518	14
1914	35	5,145,452	588,373	11
1915	36	4,861,734	1,051,405	22
1916	36	7,696,813	1,507,679	20

The total number of springs reporting production was 36, as follows:

Allouez Spring, Green Bay, Brown County.
Almanaris Spring, Waukesha, Waukesha County.
Andersons Waukesha Spring, Waukesha, Waukesha County.
Arbutus Mineral Spring, Oconto, Oconto County.
Arcadian Spring, Waukesha, Waukesha County.
Bay City Springs, Ashland, Ashland County.
Bethania Spring, Osceola, Polk County.
Bethesda Spring, Waukesha, Waukesha County.
Castalia Spring, Wauwatosa, Milwaukee County.
Chippewa Spring, Chippewa Falls, Chippewa County.
Clysmic Spring, Waukesha, Waukesha County.
Crystal Spring, Sheboygan, Sheboygan County.
Crystal Springs, Waupaca, Waupaca County.

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Darlington Mineral Spring, Darlington, Lafayette County.
Deep Rock Spring, Palmyra, Jefferson County.
Elysian Spring, Prairie du Chien, Crawford County.
Famous Spring, Menominee Falls, Waukesha County.
Fontana Lithia Spring, Walworth, Walworth County.
Glenn Rock Spring, Waukesha, Waukesha County.
High Rock Spring, Waukesha, Waukesha County.
Horeb Spring, Waukesha, Waukesha County.
Kusche Spring, Oshkosh, Winnebago County.
Lebenswasser Spring, Green Bay, Brown County.
Neeskara Spring, Wauwatosa, Milwaukee County.
Rainbow Mineral Spring, Wautoma, Waushara County.
Roxo Spring, Waukesha, Waukesha County.
Sheboygan Spring, Sheboygan, Sheboygan County.
Sheridan Mineral Springs, near Lake Geneva, Walworth County.
Silurian Spring, Waukesha, Waukesha County.
Silver Springs, Madison, Dane County.
Soda-Lithia Spring, Fussville, near Menominee Falls, Waukesha County.
Sulphur Mineral Springs, Oshkosh, Winnebago County.
Waukesha AAAA Spring, Waukesha, Waukesha County.
Waukesha Fox Head Spring, Waukesha, Waukesha County.
White Rock Spring, Waukesha, Waukesha County.
Wilnette Spring, Cooper Station, Racine County.

WYOMING.

Sales from 3 springs in Wyoming in 1916 amounted to 53,891 gallons, valued at $7,269, or a decrease, as compared with the output for 1915, of 21 per cent in quantity and 20 per cent in value. Two springs which reported sales in 1915 were inactive in 1916. Skyrok Water was formerly called Rocky Mountain Spring. One small resort and 1 mineral-water bathing establishment were operated, and about 1,000 gallons of mineral water also was used in the manufacture of soft drinks.

The names of the 3 reporting springs are as follows:

Big Horn Hot Springs, Thermopolis, Hot Springs County.
Paulson Well, Saratoga, Carbon County.
Skyrok Water, Granite Canon, Laramie County.

COMPARISON OF AMERICAN AND EUROPEAN MINERAL WATERS.

By Alfred A. Chambers.

IMPORTS AND DOMESTIC PRODUCTION.

The United States is surpassed by few countries in the number and variety of its mineral waters; nevertheless, the importation of mineral waters was, up to the beginning of the European war, a growing industry. Nine-tenths of the imported mineral waters consumed in the United States in 1913 came from Germany, France, and Austria-Hungary; the countries next in rank, but with much smaller imports, were Spain, Italy, Belgium, and England. The effect of the war is best shown by the following table, in which the figures represent general imports rather than imports for consumption and therefore differ slightly from those in the table on page 470:

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Mineral waters imported into and produced in the United States, 1913–1916, in gallons.[a]

	1913	1914	1915	1916
Imports:				
Austria-Hungary	384,960	314,592	37,197	0
France	1,162,878	1,304,685	899,205	1,425,546
Germany	1,786,839	1,029,753	511,677	124,716
Italy	85,181	70,980	31,800	33,636
Netherlands	19,155	1,125	9,549	29,820
Spain	72,747	72,225	51,855	40,563
England	32,568	30,423	44,178	87,788
Canada	10,077	2,475	4,413	4,545
All other countries	58,458	27,426	18,513	26,826
	3,562,863	2,853,684	1,608,387	1,723,440
Production in the United States[b]	57,867,399	54,358,466	52,113,503	55,928,461

[a] Statistics of imports furnished by the Bureau of Foreign and Domestic Commerce, Department of Commerce, from their statistics on "general imports." They include all mineral water imported into the United States during the year. Figures showing the importation of mineral waters for consumption only are not available by countries. (See table on p. 470.)

[b] Statistics of production collected by U. S. Geol. Survey.

The total imports of mineral waters have decreased more than 50 per cent in four years—from 3,562,863 gallons in 1913 to 1,723,440 gallons in 1916. The imports from Austria-Hungary, which in 1913 amounted to 384,960 gallons, have been entirely cut off. The trade in mineral waters with Germany has decreased from 1,786,839 gallons in 1913 to 124,716 gallons in 1916. Imports from France have increased more than 250,000 gallons in the same period, and England's trade has shown little change. It is worthy of note that, large as these figures for imports are, they represent only a relatively small percentage of the total consumption of mineral waters in the United States. Rarely do they amount to more than 6 per cent of the total consumption, and for the years 1913 to 1916, inclusive, they are somewhat less than 4.5 per cent. The accompanying diagram (p. 502) shows the condition of the mineral-water import trade from Germany, France, Austria-Hungary, and England from 1909 to 1916, inclusive.

BASIS FOR COMPARISON.

INTRODUCTION.

Those who have found it difficult or impossible to obtain waters that were previously imported will doubtless be interested in the possibility of substituting domestic waters for certain famous mineral waters of Europe as indicated by the following comparisons of analyses of mineral waters from this country and from abroad. In the analyses only the more common constituents are given, and for the convenience of those desiring more detailed information regarding these and other analyses a bibliography has been appended. To discover two or more natural waters each of whose dozen or more constituents is exactly the same in kind and concentration would be difficult if not impossible, but an attempt is made here to show that the waters compared are similar in chemical character, degree of mineralization, and relative proportion of various constituents. As medical practice varies sometimes as much as 100 per cent in the dosage of many of the inorganic substances present in natural solu-

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tions, it seems reasonable to assume that waters differing not too widely in composition might be used for the same purpose with similar if not identical physiologic effects.

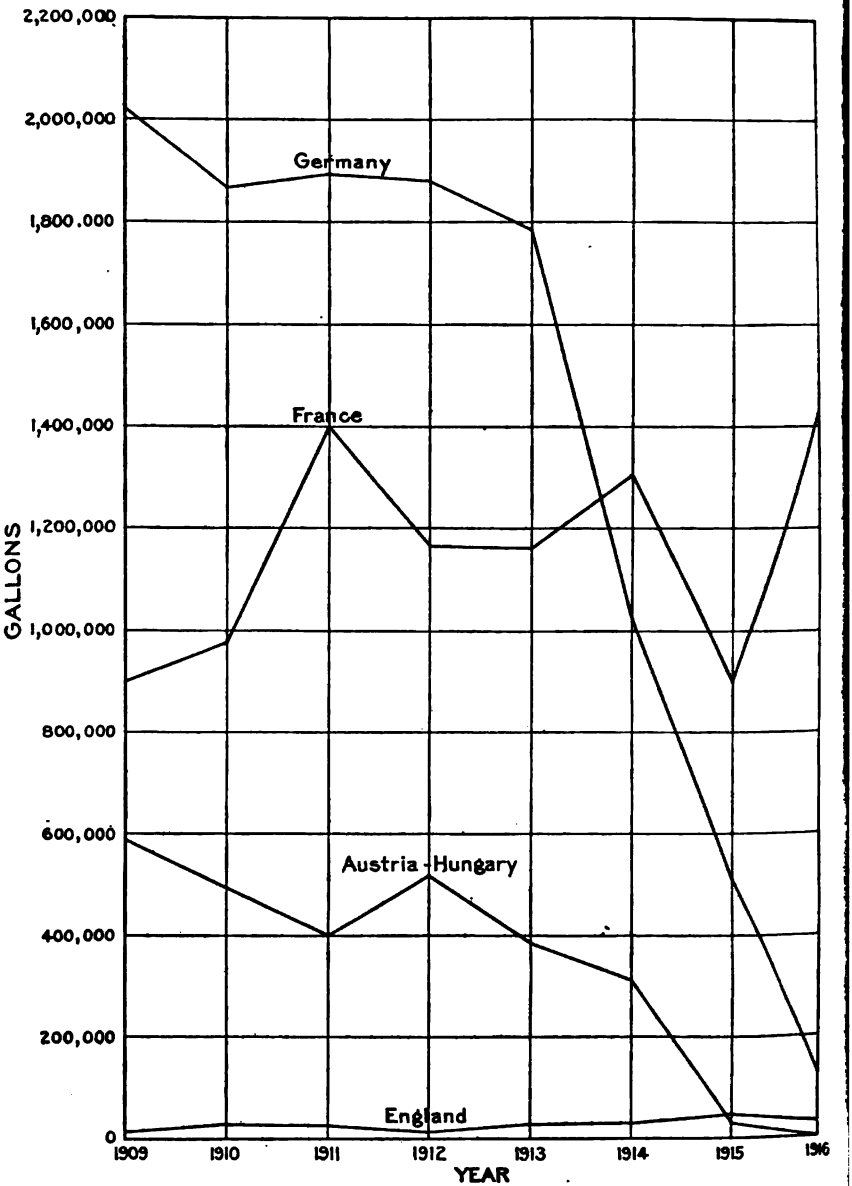

FIGURE 12.—Diagram showing general imports of mineral waters into the United States from Austria-Hungary, England, France, and Germany, 1909 to 1916, inclusive.

The American waters chosen for this study have been those for which the analyses were at hand. A more exhaustive study would no doubt reveal many others of equal value for comparison.

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Many more comparisons could be made. Hinsdale[1] gives a list that includes about 40 European waters and that indicates for each 1 to 7 similar American waters. As a large part of the cost of imported waters is chargeable to freight and handling, it would seem unnecessary to pay high prices for imported waters if equally satisfactory and less expensive waters can be obtained in this country.

When American springs are more fully investigated and exploited, and when better accommodations for hydrotherapeutic treatment are available, it may be hoped that in the United States counterparts of nearly all the famous spring resorts in Europe will be developed. There is also a satisfaction in the assurance that if mineral waters are a war-time necessity in convalescent hospitals, supplies from abroad may be completely shut off without deprivation to patients in this country.

Five common types of mineral waters are discussed here—chalybeate (or iron), carbonate, sulphide or "sulphur," chloride, and sulphate waters.

CHALYBEATE (OR IRON) WATERS.

The chalybeate or iron waters compared are those from Flat Well No. 2, at Saratoga Springs, N. Y., and Chloride of Iron Spa, at Harrogate, England. The analyses show that both waters are high in mineral content, the American water being much higher than the water from England. On examination of the columns headed "Percentage of anhydrous residue," however, which indicate the relative proportion of the dissolved constituents, certain similarities are at once apparent. For instance, in both sodium is the predominant element among the bases, and it is present in nearly equal percentage; likewise among the acid radicles the chloride predominates. The percentage of chloride is much higher in the Chloride of Iron Spa than in Flat Well No. 2, but, as may be seen by the statement of results in parts per million, the quantities are almost identical. Iron is present in exceptionally large amount in both waters, yet it constitutes only 3.2 and 3.4 per cent, respectively, of the total quantity of dissolved mineral matter. The percentages of silica, calcium, magnesium, and potassium are all comparatively low, and are distinctly lower than those of sodium and chloride. The waters differ markedly with respect to the amount of carbonate and free carbon dioxide present. The American water contains 20.4 per cent carbonate and is supersaturated with free CO_2; whereas the English water contains only 1.2 per cent carbonate, and no free CO_2 is reported. Sulphate constitutes less than 0.05 per cent of the mineral matter in both waters and hence has been reported as 0.0 per cent. It is exceptional to find such small quantities of sulphate in waters of such high concentration, which further illustrates the similarity of the two waters.

[1] Hinsdale, Guy, Some analogous European and American mineral springs: Am. Climatological Assoc. Trans., vol. 17, pp. 263–265, 1901.

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Chemical composition of chalybeate (or iron) waters.

Constituent.	Flat Well No. 2, Saratoga Springs, N. Y.[a]		Chloride of Iron Spa, Harrogate, England.[b]	
	Milligrams per liter.	Percentage of anhydrous residue.	Parts per million.	Percentage of anhydrous residue.
Silica (SiO_2)	57	0.5	20	0.3
Iron (Fe)	245	3.2	158	3.4
Aluminum (Al)	70	1.2		
Calcium (Ca)	689	6.3	482	7.2
Magnesium (Mg)	249	2.3	206	3.1
Sodium (Na)	2,782	25.3	1,552	23.3
Potassium (K)	279	2.5	23	.4
Carbonate radicle (CO_3)	2,247	20.4	81	1.2
Sulphate radicle (SO_4)	2.9	.0	1.3	.0
Chloride radicle (Cl)	4,227	38.3	4,025	60.3
Nitrate radicle (NO_3)	Trace.	.0		
Barium (Ba)			50	.8
	10,848	100.0	6,598	100.0
Free CO_2	(c)			

[a] Analyst, New York State Department of Health; recalculated from hypothetical combinations as published in pamphlet issued by the Commissioners of the New York State Reservation, Saratoga Springs, N. Y. (2d ed., 1914).

[b] Analyst, C. H. Bothamley; recalculated from percentage of anhydrous residue as cited by Clarke, F. W., The data of geochemistry, 3d ed.: U. S. Geol. Survey Bull. 616, p. 184, 1916.

[c] Supersaturated.

CARBONATE WATERS.

Two rather highly mineralized waters of the carbonate type—that is, containing carbon dioxide, both free and combined, in large quantity—are represented by the following analyses of the Manitou and the famous Apollinaris waters, in both of which sodium predominates among the bases and carbonate among the acids. They may, therefore, be considered similar in that the same constituents are present in greatest percentage in both. Both contain the other bases in subordinate amounts, but the proportion of calcium is much higher in the Manitou water than in the Apollinaris and the proportion of magnesium is nearly twice as high in the Apollinaris as in the Manitou. The percentages of carbonate are, respectively, 44 and 41.6, figures which for this discussion may be considered equal. Sulphate and chloride are rather minor in amount compared to the carbonate, but the ratios and amounts are nearly the same. Apollinaris water is reported to contain 1,988 cubic centimeters of carbon dioxide per 1,000 grams. No determination of the amount of this gas was made in the analysis of Manitou water, but the water is said to be supersaturated, a condition which no doubt adds much to its attractiveness for table use.

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Chemical composition of carbonate waters.

Constituent.	Manitou table water, from Manitou Springs, Manitou, Colo.[a]		Apollinaris water, from Apollinaris Brunnen, Ahrweiler, Germany.[b]	
	Parts per million.	Percentage of anhydrous residue.	Parts per million.	Percentage of anhydrous residue.
Silica (SiO_2)	47	1.6	8.0	0.3
Iron and aluminum (Fe+Al)	1.8	.0	[c] 20	.8
Calcium (Ca)	458	15.3	24	.9
Magnesium (Mg)	79	2.6	127	5.0
Sodium (Na)	551	18.4	827	32.4
Potassium (K)	71	2.4	Trace.	.0
Carbonate radicle (CO_3)	1,313	44.0	1,061	41.6
Sulphate radicle (SO_4)	219	7.3	203	8.0
Chloride radicle (Cl)	250	8.4	282	11.0
Nitrate radicle (NO_3)	None.	.0	.....	.....
Free CO_2 (at 0° C. and 760 millimeters)	2,991 [d]	100.0	2,552 [e]	100.0 .....

[a] Analyzed by the Bureau of Chemistry, United States Department of Agriculture; published in U. S. Dept. Agr. Bur. Chemistry Bull. 91, p. 70, 1905.
[b] Analyst not given; recalculated from hypothetical combinations in parts per 10,000 as published in Mineral waters, pp. 11–12, New York, P. Scherer & Co., 1882.
[c] Oxides of iron and aluminum ($Fe_2O_3+Al_2O_3$).
[d] Supersaturated.
[e] 1,988 cubic centimeters per 1,000 grams.

SULPHIDE OR "SULPHUR" WATERS.

"Sulphur" waters in wide variety occur in this country, and there is every reason to believe that they can adequately supply all needs for waters of this type. For comparison the analysis of the water of the "Trinkquelle," at Bad Nenndorf, Hesse-Nassau, Germany, one of the most famous foreign waters of this type, is shown below, together with the composition of the water of White Sulphur Spring, at Richfield Springs, N. Y. Both are calcium-sulphate waters—that is, calcium is predominant among the bases and sulphate among the acids; and both are rich in hydrogen sulphide gas, the constituent which gives them their characteristic odor and popular name, "sulphur" waters. Silica is relatively low in both waters. Iron and aluminum are each reported as trace in the American water, and, as they were not determined in the foreign water, it may be assumed that they were present therein in only very small quantity. Calcium and magnesium are present in rather large amount and in nearly the same proportion in both waters. Sodium is higher in the water from the "Trinkquelle," but potassium is low in both. Carbonate and sulphate radicles are only slightly higher in the foreign water; chloride radicle is considerably higher. The water from White Sulphur Spring contains less combined sulphur but more hydrogen sulphide gas than the water from "Trinkquelle."

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Chemical composition of sulphide or "sulphur" waters.

Constituent.	White Sulphur Spring, one of the group of Richfield Springs, N. Y.[a]		"Trinkquelle," at Bad Nenndorf, Hesse-Nassau, Germany.[b]	
	Parts per million.	Percentage of anhydrous residue.	Parts per million.	Percentage of anhydrous residue.
Silica (SiO_2)	11	0.4	22	0.8
Iron (Fe)	Trace.	.0	.....	.....
Aluminum (Al)	Trace.	.0	.....	.....
Calcium (Ca)	567	23.7	555	19.0
Magnesium (Mg)	108	4.5	129	4.4
Sodium (Na)	21	.9	202	6.9
Potassium (K)	13	.5	21	.7
Carbonate radicle (CO_3)	224	9.3	278	9.5
Sulphate radicle (SO_4)	1,443	60.0	1,485	51.0
Chloride radicle (Cl)	5.7	.2	189	6.5
Sulphide (S)	[c] 13	.5	[d] 34	1.2
	2,406	100.0	2,915	100.0
Hydrogen sulphide (H_2S) in cubic centimeters per liter at 0° C. and 760 millimeters	62	.....	46	.....

[a] Analyst, C. F. Chandler; recalculated from hypothetical combinations in grains per gallon as published in U. S. Geol. Survey Bull. 32, p. 37, 1886.
[b] Analysis by Bunsen; recalculated from hypothetical combinations in grains per gallon as published in Special report on mineral waters: Kansas Univ. Geol. Survey, vol. 7, p. 273, 1902.
[c] Recalculated from Na_2S.
[d] Recalculated from CaS.

The following table shows the composition of water from the Taylor Sulphur Spring, Cal., and the Sulphur Spring, Aix-les-Bains, France. The French water is of the calcium-carbonate type and the American water is of the sodium-sulphate type. The difference, however, is not essential, as the French water also contains a relatively large amount of sulphate. The waters are of nearly the same concentration, both contain about the same relative amount of free carbon dioxide, and the hydrogen sulphide reported is exactly the same.

Chemical composition of sulphide or "sulphur" waters.

Constituent.	Taylor Sulphur Spring, near Santa Rosa, Cal.[a]		Sulphur Spring, Aix-les-Bains, France.[b]	
	Parts per million.	Percentage of anhydrous residue.	Parts per million.	Percentage of anhydrous residue.
Silica (SiO_2)	20	4.2	5.0	1.2
Iron (Fe)	Trace.	.0	4.2	1.4
Aluminum (Al)	8.4	3.2	8.7	3.8
Calcium (Ca)	7.0	1.4	64	15.0
Magnesium (Mg)	35	7.1	19	4.5
Sodium (Na)	93	18.9	34	8.0
Potassium (K)	6.3	1.3	.....	.....
Carbonate radicle (CO_3)	35	7.1	112	26.4
Sulphate radicle (SO_4)	220	44.8	151	35.5
Chloride radicle (Cl)	59	12.0	18	4.2
	484	100.0	416	100.0
Free CO_2 (cubic centimeters per liter at 0° C. and 760 millimeters).	23	.....	14	.....
H_2S (cubic centimeters per liter at 0°C. and 760 millimeters).	28	.....	28	.....

[a] Analyst, Winslow Anderson; cited by Waring, G. A., U. S. Geol. Survey Water-Supply Paper 338, p. 257, 1915.
[b] Analyst, Bonjeau; recalculated from hypothetical combinations in grains per gallon as published in Special report on mineral waters: Kansas Univ. Geol. Survey, vol. 7, p. 273, 1902.

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CHLORIDE WATERS.

Considered as carbonated solutions containing large proportions of sodium and chloride radicles, the water from the Arondack Spring, Saratoga, N. Y., resembles that from the famous Marienquelle. The Arondack water, however, contains considerably more sulphate than Marienquelle, and herein lies the chief difference between the two. Silica was not reported in the analysis of the water from Marienquelle, and iron and aluminum are low in both springs. Calcium and magnesium together constitute 4 per cent of the total mineral matter in the American water and 5.6 per cent in the foreign—rather small quantities to compare with the corresponding figures for sodium which are, respectively, 28.2 and 33.4 per cent. Chloride, although high in both waters, is 12.7 per cent higher in that from Marienquelle. The concentrations are almost identical, however, and both contain free carbon dioxide. The amount of this gas was not determined in analyzing the Marienquelle, but the analyst reports 396 cubic centimeters per 1,000 grams in the Arondack water.

Chemical composition of chloride waters.

Constituent.	Arondack water, Saratoga, N. Y.[a]		Marienquelle, Bavaria, Germany.[b]	
	Parts per million.	Percentage of anhydrous residue.	Parts per million.	Percentage of anhydrous residue.
Silica (SiO_2)	9.2	0.3	(c)	(c)
Iron (Fe)	3.5	.1	2.7	0.1
Aluminum (Al)			Trace.	.0
Calcium (Ca)	26	.9	123	4.2
Magnesium (Mg)	91	3.1	40	1.4
Sodium (Na)	827	28.2	982	33.4
Potassium (K)	145	4.9	Trace.	.0
Carbonate radicle (CO_3)	136	4.6	228	7.8
Sulphate radicle (SO_4)	504	17.1	Trace.	.0
Chloride radicle (Cl)	1,186	40.4	1,566	53.1
Nitrate radicle (NO_3)	12	.4	.....	.....
	2,940	100.0	2,942	100.0
Free CO_2 (cubic centimeters per 1,000 grams at 0° C. and 760 millimeters)	396	.....	(d)	.....

[a] Analyzed by Bureau of Chemistry, United States Department of Agriculture; published in U. S. Dept. Agr. Bur. Chemistry Bull. 91, p. 87, 1905.
[b] Analyst, A. Lipp, Ber. Deutsch. chem. Gesell., vol. 30, p. 309, 1897; recalculated from percentage of anhydrous residue as cited by Clarke, F. W., U. S. Geol. Survey Bull. 616, p. 184, 1916.
[c] Silica not reported; probably present in small amount.
[d] Free CO_2 present, but amount not determined.

SULPHATE WATERS.

An analysis of Sprudel water, one of the famous waters of Carlsbad, Austria-Hungary, is similar to that from Salt Condiment Spring, one of the group at Alum Rock Park, Cal. The California water contains somewhat more mineral matter than the Carlsbad water, but both would be classed as high in total solids, as shown by the sum of the constituents determined. Both contain relatively high percentages of sodium and sulphate and smaller quantities of other bases and acids. The California water contains less sodium but more sulphate and chloride than the Carlsbad water, and the latter carries more carbonate and free carbon dioxide.

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Chemical composition of sulphate waters.

Constituent.	Salt Condiment Spring, one of the group of Alum Rock Park Springs, near San Jose, Cal.[a]		Sprudel Water, from Carlsbad, Austria-Hungary.[b]	
	Parts per million.	Percentage of anhydrous residue.	Parts per million.	Percentage of anhydrous residue.
Silica (SiO_2)	60	0.9	71	1.3
Iron (Fe)	6.9	.1	1.4	.0
Aluminum (Al)			.2	.0
Calcium (Ca)	423	6.1	129	2.3
Magnesium (Mg)	160	2.3	48	.9
Sodium (Na)	1,751	25.3	1,759	31.9
Potassium (K)	45	.6	83	1.5
Carbonate radicle (CO_3)	546	7.9	1,056	19.2
Sulphate radicle (SO_4)	2,418	34.8	1,728	31.4
Chloride radicle (Cl)	1,522	22.0	631	11.5
	6,932	100.0	5,508	100.0
Free CO_2 (cubic centimeters per liter at 0° C. and 760 millimeters)	119	.....	190	.....

[a] Analyst, William Irelan, jr.; cited by Waring, G. A., U. S. Geol. Survey Water-Supply Paper 338, p. 211, 1915.

[b] Analysts, Ludwig & Mauthner; recalculated from hypothetical combinations in parts per 10,000 as cited by Pichler, Dr. W., Nouveau guide de Carlsbad, p. 90, 1880.

OPPORTUNITIES FOR EXPORT TRADE.

The Bureau of Foreign and Domestic Commerce, Department of Commerce, has repeatedly called attention through its Daily Consular and Trade Reports to the possibility of establishing an American export business in mineral waters with various countries. Conditions produced by the war have made it impossible to obtain certain European waters, and the time to establish such an export trade is especially favorable. Canada, Cochin China, India, several South American countries, and others have been suggested by the Department of Commerce as offering exceptional opportunities for export trade in mineral waters—opportunities that can, of course, be seized only if transportation facilities become available.

BIBLIOGRAPHY.[1]

The following list of publications has been prepared to answer requests for information regarding the chemical composition of waters from American springs. The list is not by any means exhaustive, hundreds of analyses of mineral waters having been published elsewhere; it mentions chiefly reports that are notable for the number of analyses of mineral waters and reports on especially well-known springs. Those seeking analyses of water that are not mentioned in the following publications are advised to consult published reports of the United States Geological Survey, of State geological surveys, of State boards of health, and of agricultural experiment stations.

[1] Chiefly from Published analyses of American mineral waters: U. S. Geol. Survey Mineral Resources, 1913, pt. 2, pp. 433–434, 1914.

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Publications on mineral waters, chiefly from American springs.

ANDERSON, WINSLOW, Mineral springs and health resorts of California, with a complete chemical analysis of every important mineral water in the world, San Francisco, Cal., The Bancroft Co., 1892.

BAILEY, E. H. S., Special report on mineral waters: Kansas Univ. Geol. Survey, vol. 7, 1902.

Analyses of 115 ground waters are given, including the well-known mineral waters of the State. Analyses of many other noted waters are quoted, among which may be mentioned analyses of Crab Orchard, Hunyadi Janos, Carabana, Kissingen, Sprudel, and Pullna waters. Special chapters deal with the classification of mineral waters and their therapeutic action.

BARTOW, EDWARD, and others, The mineral content of Illinois waters: Illinois Water Survey Bull. 4, 1908.

Analyses of many ground waters are given, and special chapters deal with the geologic occurrence and classification of the waters and the medicinal springs of Illinois.

BLATCHLEY, W. S., The mineral waters of Indiana: Indiana Dept. Geol. and Nat. Res. Ann. Rept., vol. 26, pp. 11–158, 1901.

Descriptions of more than 100 mineral springs are given and analyses of the waters from many of them are quoted. The same volume (pp. 159–226) contains a discussion of the medicinal properties and uses of Indiana mineral waters by Dr. Robert Hessler.

COHEN S. S. (editor), System of physiologic therapeutics, vol. 9, Philadelphia, Pa., P. Blakiston's Sons & Co., 1902.

This volume contains a chapter by Dr. A. C. Peale on the classification of mineral waters with special reference to those of the United States, and the composition of many waters is discussed.

FROEHLING and ROBERTSON. Mineral waters and spring resorts of Virginia; a handbook on the minerals and mineral resources of Virginia, pp. 97–159, Richmond, 1907.

This handbook was published for distribution at the Jamestown Exposition, Norfolk, Va., 1907. About 60 resorts are described, and analyses of the waters at most of them are quoted.

GOOCH, F. A., and WHITFIELD, J. E., Analyses of waters of the Yellowstone National Park: U. S. Geol. Survey Bull. 47, 1888.

The methods of analysis are described and analyses of the waters of the geysers, pools, and hot and cold springs are given. (Out of print; available for consultation in most large libraries.)

HARE, R. F., and MITCHELL, S. R., Composition of some New Mexico waters: New Mexico Coll. Agr. and Mech. Arts Agr. Exper. Sta. Bull. 83, 1912.

In a collection of miscellaneous analyses reports on the composition of the waters of Carlsbad (N. Mex.) Mineral Springs, Mimbres Hot Springs, San Antonio Springs, Aztec Mineral Springs, and some others are given.

HAYWOOD, J. K., Analyses of the waters of the Hot Springs of Arkansas: U. S. Dept. Interior, 1912.[1]

Analyses of 46 waters are given. The same report contains a geologic sketch of Hot Springs, Ark., by W. H. Weed.

——— Mineral waters of the United States: U. S. Dept. Agr. Bur. Chemistry Bull. 91, 1905.

Analyses are given of 55 American spring waters, including 13 Saratoga waters.

HINSDALE, GUY, Analogous European and American mineral springs: Am. Climatological Assoc. Trans., vol. 17, pp. 263–265, 1901.

KELLY, CLYDE, and ANSPACH, E. V., A preliminary study of the waters of the Jemez Plateau, N. Mex.: New Mexico Univ. Bull. 71, 1913.

Analyses of Sulphur, Soda Dam, Jemez Hot, Indian, San Ysidro, and Phillip's springs are reported.

LANE, A. C., Lower Michigan mineral waters: U. S. Geol. Survey Water-Supply Paper 31, 1899.

Analyses of 40 mineral and several other ground waters are discussed in relation to their geologic source.

[1] Purchasable from the Superintendent of Documents, Washington, D. C., for 10 cents, payable in advance.

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MILFORD, L. R., Analyses of the Saratoga mineral waters: Jour. Ind. and Eng. Chemistry, vol. 4, p. 593, 1912; vol. 5, p. 24, and p. 557, 1913; vol. 6, p. 207, 1914.

This series of four articles gives new analyses of all the important Saratoga waters.

PEALE, A. C., Geographical distribution of the mineral springs of the United States: Internat. Med. Mag., November, 1895.

——— Natural mineral waters of the United States: U. S. Geol. Survey Fourteenth Ann. Rept., pt. 2, pp. 49–88, 1894.

This report contains a general discussion of the origin, flow, geologic relations, and utilization of mineral waters, and a list of several hundred American mineral spring resorts. (Out of stock for free distribution; Part II, which includes several other papers, can be purchased from the Superintendent of Documents, Washington, D. C., for $2.10, payable in advance.)

——— Lists and analyses of the mineral springs of the United States: U. S. Geol. Survey Bull. 32, 1886.

About 2,800 mineral springs are listed and about 800 analyses are quoted. (Out of print; available for consultation in most large libraries.)

PRATT, J. H., The mining industry in North Carolina during 1907, with a special report on the mineral waters: North Carolina Geol. and Econ. Survey Econ. Paper 15, 1908.

Analyses of 90 mineral waters are given.

Saratoga Springs, first bulletin of the commissioners of the State reservation at Saratoga Springs, Albany, N. Y., October, 1913.

Analyses of 20 Saratoga waters are given and the properties of the waters are described.

SCHERER, P., & Co., Mineral waters, foreign and domestic, with analyses, use, and source, New York, P. Scherer & Co.

Analyses of many foreign and domestic mineral waters are quoted.

SCHWEITZER, PAUL, A report on the mineral waters of Missouri: Missouri Geol. Survey, vol. 3, 1892.

About 80 analyses of Missouri ground waters are given. Analyses of Vichy, Sprudel, Kreutzbrunnen, Spa, St. Moritz, Aix-les-Bains, and other foreign waters are quoted. The classification of mineral waters and their therapeutic action are discussed.

SELLARDS, E. H., A preliminary report on the underground water supply of central Florida: Florida Geol. Survey Bull. 1, 1908.

Analyses of 14 large springs are given.

SHEPARD, J. H., The artesian waters of South Dakota: South Dakota Agr. Coll. and Exper. Sta. Bull. 41, 1895.

Analyses of about 50 deep waters are given.

SKINNER, W. W., American mineral waters; The New England States: U. S. Dept. Agr. Bur. Chemistry Bull. 139, 1909.

This pamphlet contains analyses of New England spring waters and the results of bacteriological examinations of them.

WARING, G. A., Springs of California: U. S. Geol. Survey Water-Supply Paper 338, 1914.

Analyses of practically all California mineral waters are included.

——— Mineral springs of Alaska: U. S. Geol. Survey Water-Supply Paper 418, 1917.

Analyses of about 30 springs are included in this report.

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CLAY-WORKING INDUSTRIES.[1]

By JEFFERSON MIDDLETON.

GENERAL CONDITIONS.

This report deals with the products of the clay-working industries as well as with clay mining, and the tables are made up to show the output of manufactured clay products as best expressing the production of clay.

The year 1916 in the clay-working industries was one of general progress. In spite of strikes, scarcity of labor, increased cost of materials, and congestion in transportation the output of 1916 was much larger than in any preceding year. In some sections of the country the business in brick and tile lagged during the earlier part of the year, but later was unusually active, reflecting the general prosperity of the country. The total value of all clay products marketed was $207,260,091, an increase of $44,139,859, or 27 per cent. This is the greatest value recorded in these industries and is nearly $26,000,000 more than the highest previous record.

The refractories branch of the industries, the products of which are so essential, both to modern civilization and to military operations, showed the largest increase, and was followed next in order by the great structural material, common brick. Only fancy brick and enameled brick, both minor items in the total output, decreased in value, and the decrease in these was very small.

Both divisions of the industry—(1) brick and tile, and (2) pottery—showed large increase, $33,248,005, or 26 per cent, for the former and $10,891,854, or 29 per cent, for the latter, compared with 1915.

The progress throughout the industries was so general that but few special features need be noticed—for example, the large increase in the production and value of common building brick and of fire brick. The continued increase in output of common brick in Cook County, Ill., was also an interesting feature of the year's record. The output of common brick in that county in 1916 was greater by 130,568,000 brick than the output of the New York portion of the Hudson River region.

The engineering and refractory products, vitrified brick, draintile, sewer pipe, fire brick, and stove lining, valued at $67,305,448, showed an increase of $15,636,664, or 30 per cent, and the clay structural materials, valued at $84,643,252, showed a net increase of $14,234,136, or 20 per cent, in 1916 compared with 1915.

In the brick and tile industry increase was shown in the quantity of common brick, front brick, and fire brick, and decrease only in the quantity of vitrified brick or block marketed in 1916.

[1] Tables of production were prepared by Miss Belle Worth Bagley and Miss K. W. Cottrell, tables of imports and exports by J. A. Dorsey, and tables of building operations by Miss Cottrell.

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The imports of clay products, 97 to 98 per cent of which in recent years have been pottery, have decreased in value in all but three years since 1907, when they attained their maximum, and the value of imports in 1916 was only 42 per cent of the value of those in 1907. The proportion of domestic production of pottery to consumption in 1916 was the highest yet recorded, reaching 92 per cent. The great decline in the last few years in imports of pottery has undoubtedly been due to the war, but the steady improvement in the quality of domestic wares in body decoration and finish has had much to do with the increasing popularity of domestic pottery, and it is probable that at the close of the war American pottery will have obtained a firmer hold on the popular fancy than ever before. The opportunity to develop the foreign markets for American pottery caused by the decreased shipment from Europe has been largely lost by reason of the inability of the domestic potters to supply all the home demand.

The exportation of clay products, an unimportant factor in the industries, showed a large increase in 1916, the value of exports in that year being $4,855,530, about 3 per cent less than the maximum in 1912. Fire brick was the principal clay product exported, its value constituting 50 per cent of all exports. Canada is the best foreign market for clay products exported from the United States, more than half of our exports going to that country in 1916.

In their statements to the Geological Survey the producers report quantities for common brick, front brick, vitrified brick or block, clay fire brick, and silica fire brick, but not for fancy brick or for enameled brick. Front brick and fire brick reached their maximum quantity in 1916. The average price per thousand for these various varieties increased as follows: Common brick, 53 cents; vitrified brick or block, 17 cents; clay fire brick, $2.61; and silica fire brick, $3.53. These are certainly very small advances, except in the refractory brick, compared with the increase in the cost of labor and materials. Four varieties of brick and tile and miscellaneous products reached their maximum value in 1916.

The number of firms reporting sales continues to decrease, the number for 1916 being the smallest in the history of the industry and less than half of the maximum number reported for 1899. This decrease is caused principally by the elimination of the smaller plants ascribed to the encroachment of cement or concrete and also to the consolidation of plants for their more efficient management. The increase in the size of the operations is shown by the average increase in the value per operator reporting, which increased from $13,760 in 1899 to $60,744 in 1916. The number of operators does not mean the number of plants, as one operator often has more than one plant, and some operators have a dozen or more. Clay products, except the highest grades, are made for local consumption, their low value preventing transportation for any considerable distances. Hence, local conditions, including weather, seriously affect some branches of the clay-working industries. Imports are chiefly of the highest grades of ware, principally pottery, and the European war has had little direct effect on the brick and tile industries. Some of these wares, however, have been made from imported clays, especially from the high-grade fire clays from Germany, and the decrease in the imports of these clays has seriously affected the manufacture of crucibles, lead pencils, and glass-house pots.

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ACKNOWLEDGMENTS.

The writer again desires to thank the clay workers of the country for their cooperation, without which this report would be impossible. Thanks are also extended to the clay-working press for its support and appreciation and to the officials who have supplied information concerning the building operations of the larger cities of the country.

PRODUCTION.

PRODUCTION BY STATES.

The value of the brick and tile products as classified in this report forms a little more than three-fourths, and that of the pottery products a little less than one-fourth of the total, the pottery products having gradually increased from about a fifth a few years ago. Every State is a producer of clay wares. Of the territories, Alaska and Hawaii reported none for 1916. A small production was reported from the District of Columbia and from Porto Rico. In Nevada and Rhode Island there were not a sufficient number of producers reporting to permit the publication of State totals without disclosing confidential information, so that statistics for these States have been combined with those of contiguous States.

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Value of the products of clay in the United States in 1915 and 1916, with increase or decrease.

State.	1915			1916			Increase or decrease, 1916.	
	Brick and tile.	Pottery.	Total.	Brick and tile.	Pottery.	Total.	Value.	Per cent.
Alabama	$1,177,725	$15,297	$1,193,022	$1,497,496	$22,805	$1,520,301	+ $327,279	+ 27.43
Arizona	97,208		97,208	106,149		106,149	+ 8,941	+ 9.20
Arkansas	323,682	20,285	343,967	521,569	(a)	521,569	+ 177,602	+ 51.63
California	3,231,281	368,094	3,599,375	3,645,629	517,797	4,163,426	+ 564,051	+ 15.67
Colorado	1,202,220	62,885	1,265,105	1,818,470	111,569	1,930,039	+ 664,934	+ 52.56
Connecticut and Rhode Island	1,518,773	(b)	1,518,773	1,762,653	(b)	1,762,653	+ 243,880	+ 16.06
Delaware	145,694		145,694	187,388		187,388	+ 41,694	+ 28.62
District of Columbia	131,134	(a)	131,134	129,394	(a)	129,394	− 1,740	− 1.33
Florida	203,414		203,414	226,362		226,362	+ 22,948	+ 11.28
Georgia	1,826,842	18,177	1,845,019	2,348,781	13,201	2,361,982	+ 516,963	+ 28.02
Idaho and Nevada	128,382		128,382	212,451		212,451	+ 84,069	+ 65.48
Illinois	13,843,046	948,892	14,791,938	16,507,845	1,125,506	17,633,351	+ 2,841,413	+ 19.21
Indiana	5,892,596	1,198,034	7,090,630	8,032,960	1,634,353	9,667,313	+ 2,576,683	+ 36.34
Iowa	6,738,190	5,425	6,743,615	7,379,289	(a)	7,379,289	+ 635,674	+ 9.43
Kansas	2,110,877	(a)	2,110,877	2,747,803		2,747,803	+ 636,926	+ 30.17
Kentucky	2,332,451	108,839	2,441,290	3,438,146	121,111	3,559,257	+ 1,117,967	+ 45.79
Louisiana	385,002	(a)	385,002	360,855	(a)	360,855	− 24,147	− 6.27
Maine	488,079	(a)	488,079	546,725	(a)	546,725	+ 58,646	+ 12.02
Maryland	1,369,738	206,718	1,576,456	1,548,295	277,575	1,825,870	+ 249,414	+ 15.82
Massachusetts	1,399,371	184,233	1,583,604	1,661,737	230,821	1,892,558	+ 308,954	+ 19.51
Michigan	2,248,068	521,989	2,770,057	2,705,054	792,716	3,497,770	+ 727,713	+ 26.27
Minnesota	1,645,913	(a)	1,645,913	2,064,362	(a)	2,064,362	+ 418,449	+ 25.42
Mississippi	351,929	15,690	367,619	508,698	11,920	520,618	+ 152,999	+ 41.62
Missouri	5,428,403	3,166	5,431,569	7,634,559	6,436	7,640,995	+ 2,209,426	+ 40.68
Montana	524,575	(a)	524,575	717,551	(a)	717,551	+ 192,976	+ 36.79
Nebraska	776,899	(a)	776,899	943,553	(a)	943,553	+ 166,654	+ 21.45
New Hampshire	484,464	(a)	484,464	473,434	(a)	473,434	− 11,030	− 2.28
New Jersey	7,916,080	8,049,338	15,965,418	9,749,524	11,064,878	20,814,402	+ 4,848,984	+ 30.37
New Mexico	240,847		240,847	257,561		257,561	+ 16,714	+ 6.94
New York	7,047,262	2,441,740	9,489,002	8,410,340	3,344,672	11,755,012	+ 2,266,010	+ 23.88
North Carolina	1,078,541	11,394	1,089,935	1,541,576	9,860	1,551,436	+ 461,501	+ 42.34
North Dakota	189,355		189,355	264,457		264,457	+ 75,102	+ 39.66
Ohio	20,909,842	15,929,779	36,839,621	25,506,344	19,441,533	44,947,877	+ 8,108,256	+ 22.01
Oklahoma	996,451		996,451	1,410,657		1,410,657	+ 414,206	+ 41.57
Oregon	341,243	(a)	341,243	299,993	(a)	299,993	− 41,250	− 12.09
Pennsylvania	20,898,282	1,827,749	22,726,031	29,630,563	2,480,127	32,110,690	+ 9,384,659	+ 41.29
Porto Rico	4,193	(a)	4,193	5,612	(a)	5,612	+ 1,419	+ 33.84
South Carolina	370,152	8,981	379,133	598,431	8,720	607,151	+ 228,018	+ 60.14
South Dakota	36,342		36,342	115,474		115,474	+ 79,132	+ 217.74

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Tennessee	1,441,831	106,389	1,548,220	1,679,319	304,638	1,983,957	+ 435,737	+ 28.14
Texas	1,911,501	65,389	1,976,890	2,749,780	88,180	2,837,960	+ 861,070	+ 43.56
Utah	699,962	(a)	699,962	885,357	(a)	885,357	+ 185,395	+ 26.49
Vermont	71,642	.....	71,642	94,779	.....	94,779	+ 23,137	+ 32.30
Virginia	1,447,802	(a)	1,447,802	1,676,723	(a)	1,676,723	+ 228,921	+ 15.81
Washington	1,454,436	(a)	1,454,436	1,589,574	(a)	1,589,574	+ 135,138	+ 9.29
West Virginia	1,773,904	4,510,623	6,284,527	1,853,468	5,780,853	7,634,321	+ 1,349,794	+ 21.48
Wisconsin	902,199	8,359	910,558	905,910	(a)	905,910	− 4,648	− .51
Wyoming	57,021	.....	57,021	90,199	.....	90,199	+ 33,178	+ 58.19
Undistributed	.....	687,923	687,923	.....	827,971	827,971	+ 140,048	+ 20.36
	125,794,844	37,325,388	163,120,232	159,042,849	48,217,242	207,260,091	+44,139,859	+ 27.06
Percentage of total	77.12	22.88	100.00	76.74	23.26	100.00	.....	.....

a Included in "Undistributed."

b Produced by Connecticut alone and included in "Undistributed."

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The generally progressive condition of the clay-working industries in the United States is shown by the fact that of the 48 totals for States and Territories represented in this table, 43 showed increase in the value of clay products marketed in 1916. In 1915, 18 States showed increase and 30 showed decrease. The decrease recorded in 1916 was small, the total for the five States being $82,815. Pennsylvania, owing to the large increase in value of fire brick—its principal clay product—showed the largest actual gain. The largest proportionate increase was in South Dakota—nearly 218 per cent. The largest decrease both actual and proportionate was in Oregon—$41,250, or 12 per cent. Twenty-six States that showed decrease in 1915 rallied and showed increase in 1916; four States showed decrease in both years, and one State (New Hampshire) showed increase in 1915 and decrease in 1916.

Value of the clay products of the United States in 1915 and 1916 and increase or decrease in 1916, by products.

Product.	1915	1916	Increase or decrease in 1916.	
			Value.	Per cent.
Common brick	$42,145,292	$49,357,411	+ $7,212,119	+ 17.11
Vitrified brick or block	12,230,899	12,236,890	+ 5,991	+ .05
Front brick	9,535,536	11,464,614	+ 1,929,078	+ 20.23
Fancy or ornamental brick	109,425	109,072	− 353	− .32
Enameled brick	835,808	827,443	− 8,365	− 1.00
Drain tile	8,879,264	10,083,647	+ 1,204,383	+ 13.56
Sewer pipe	11,259,349	13,577,006	+ 2,317,657	+ 20.58
Architectural terra cotta	4,796,062	6,466,336	+ 1,670,274	+ 34.83
Fireproofing	7,800,938	9,942,912	+ 2,141,974	+ 27.46
Tile (not drain)	5,186,055	6,475,464	+ 1,289,409	+ 24.86
Stove lining	459,341	601,776	+ 142,435	+ 31.01
Fire brick	18,839,931	30,806,129	+ 11,966,198	+ 63.52
Miscellaneous	3,716,944	7,094,149	+ 3,377,205	+ 90.86
Total brick and tile	125,794,844	159,042,849	+ 33,248,005	+ 26.43
Total pottery	37,325,388	48,217,242	+ 10,891,854	+ 29.18
Grand total	163,120,232	207,260,091	+ 44,139,859	+ 27.06

This table shows increase in 10 brick and tile products and miscellaneous products and decrease in 2. Fire brick, which showed a large increase in 1915, continued to grow in importance and showed a remarkable gain in 1916. The increase in the value of fire brick in 1916 was the largest proportionate gain recorded in any single product and is the largest actual increase in the value of any clay product ever recorded by the United States Geological Survey except the gain of common brick in 1909, which amounted to $12,485,501. Sewer pipe, which showed the largest decrease in 1915, rallied and made a large increase in 1916. Architectural terra cotta also showed a large increase in 1916. In fact all of the important brick and tile products except vitrified brick or block, which about held its own, made gains over 1915. Fancy or ornamental brick and enameled brick are the only products that decreased in value in 1916, and these decreases were very small. In 1915 nine brick and tile products decreased and three varieties and miscellaneous products increased, as compared with 1914. In 1915 brick and tile products decreased $3,793,978, or 2.9 per cent, and pottery products increased $1,927,227, or 5.4 per cent, making the net decrease $1,866,751, or 1.1 per cent.

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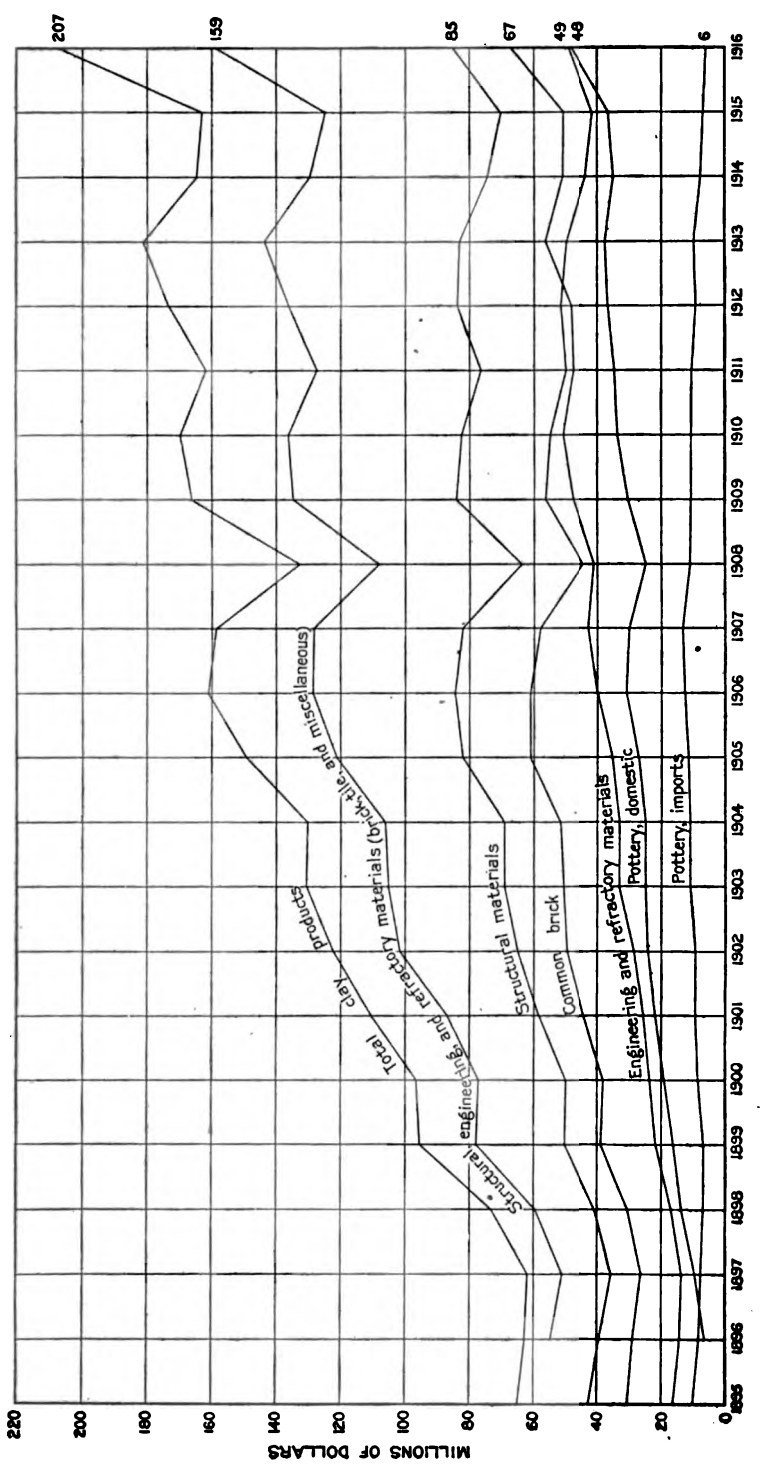

FIGURE 13.—Value of clay products sold in the United States, 1895–1916.

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Clay products sold in the United States, 1896-1916.

Year.	Number of firms reporting sales.	Common brick.			Vitrified brick or block.		
		Quantity (thousands).	Value.	Average price per thousand.	Quantity (thousands).	Value.	Average price per thousand.
1896.....	5,293	5,703,379	$29,664,043	$5.20	320,407	$2,794,585	$8.72
1897.....	5,424	5,292,532	26,430,207	4.99	435,851	3,582,037	8.22
1898.....	5,971	5,867,415	30,980,704	5.28	474,419	4,016,322	8.47
1899.....	6,962	7,695,305	39,887,522	5.18	580,751	4,750,424	8.18
1900.....	6,475	7,140,622	38,621,514	5.41	546,679	4,764,124	8.71
1901.....	6,421	8,038,579	45,503,076	5.66	605,077	5,484,134	9.06
1902.....	6,046	8,475,067	48,885,369	5.77	617,192	5,744,530	9.31
1903.....	6,034	8,463,683	50,532,075	5.97	654,499	6,453,349	9.86
1904.....	6,108	8,665,171	51,768,558	5.97	735,489	7,557,425	10.28
1905.....	5,925	9,817,355	61,394,383	6.25	665,879	6,703,710	10.07
1906.....	5,857	10,027,039	61,300,696	6.11	751,974	7,857,768	10.45
1907.....	5,536	9,795,698	58,785,461	6.00	876,245	9,654,282	11.02
1908.....	5,328	7,811,046	44,765,514	5.73	978,122	10,657,475	10.90
1909.....	5,068	9,791,870	57,251,115	5.85	1,023,654	11,269,586	11.01
1910.....	4,915	9,221,517	55,219,551	5.99	968,000	11,004,966	11.37
1911.....	4,628	8,475,277	49,885,262	5.89	948,758	11,115,742	11.72
1912.....	4,284	8,555,238	51,796,266	6.05	911,869	10,921,575	11.98
1913.....	4,065	8,088,790	50,134,757	6.20	958,680	12,138,221	12.66
1914.....	3,860	7,146,571	43,769,524	6.12	931,324	12,500,366	13.42
1915.....	3,636	6,851,099	42,145,292	6.15	953,335	12,230,399	12.83
1916.....	3,412	7,394,302	49,357,411	6.68	941,553	12,236,300	13.00

Year.	Front brick.			Fancy or ornamental brick (value).	Enameled brick (value).	Fire brick (value).	Stove lining (value).	Draintile (value).
	Quantity (thousands).	Value.	Average price per thousand.					
1896.....	270,335	$3,390,941	$12.54	$768,140	(a)	$4,944,723	(b)	$2,613,513
1897.....	310,918	3,855,033	12.40	685,048	(a)	4,094,704	(b)	2,623,305
1898.....	295,833	3,572,385	12.08	358,372	$279,993	6,093,071	(b)	3,115,318
1899.....	438,817	4,767,343	10.86	476,191	329,969	8,641,982	$416,235	3,682,394
1900.....	344,516	3,864,670	11.09	289,698	323,630	9,830,517	462,541	2,976,281
1901.....	415,343	4,709,737	11.34	372,131	463,709	9,870,421	423,371	3,143,001
1902.....	458,391	5,318,008	11.60	335,290	471,163	11,970,511	630,924	3,506,787
1903.....	433,016	5,402,881	12.48	328,387	569,689	b14,062,369	(b)	4,639,214
1904.....	434,351	5,560,131	12.80	300,233	545,397	11,167,972	(b)	5,348,555
1905.....	541,590	7,108,092	13.12	293,907	636,279	12,735,404	645,432	5,850,210
1906.....	617,489	7,895,323	12.79	207,119	773,104	14,206,868	743,414	6,543,289
1907.....	585,943	7,329,360	12.51	361,243	918,173	14,946,045	627,647	6,864,162
1908.....	584,482	6,935,600	11.87	259,556	660,862	10,696,216	529,976	8,661,476
1909.....	816,154	9,712,219	11.90	174,073	993,902	15,620,095	423,583	9,799,158
1910.....	697,857	8,590,057	12.31	179,505	832,225	18,111,474	503,806	10,389,822
1911.....	724,911	8,648,877	11.93	177,015	1,038,865	16,074,686	614,116	8,826,314
1912.....	814,007	9,455,297	11.62	225,367	1,027,314	17,877,629	516,874	8,010,250
1913.....	827,685	9,614,138	11.62	109,703	1,225,708	20,627,122	535,667	8,558,320
1914.....	810,395	9,289,623	11.46	124,459	1,075,026	16,427,547	520,585	8,522,039
1915.....	855,688	9,535,536	11.14	109,425	835,808	18,839,931	459,341	8,879,264
1916.....	1,002,752	11,464,614	11.43	109,072	827,443	30,806,129	601,776	10,083,647

a Enameled brick not separately classified prior to 1898.
b Stove lining, not separately classified prior to 1899, is included in fire brick in 1903; in miscellaneous in 1904.

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Clay products sold in the United States, 1896–1916—Continued.

Year.	Sewer pipe (value).	Architectural terra cotta (value).	Fireproofing (value).	Tile, not drain (value).	Miscellaneous (value).	Total brick and tile (value).	Pottery.	Total.
1896.....	$4,588,503	$2,359,983	$1,706,504	$1,618,127	$1,210,719	$55,654,781	$7,455,627	$63,110,408
1897.....	4,069,534	1,841,422	1,979,259	1,476,638	1,413,595	52,050,782	10,309,209	62,359,991
1898.....	3,791,057	2,043,325	1,900,642	1,746,024	2,000,743	59,898,456	14,589,224	74,487,680
1899.....	4,560,334	2,027,532	1,665,066	1,276,300	6,065,928	78,547,120	17,250,250	95,797,370
1900.....	5,842,562	2,372,568	1,820,214	2,349,420	2,896,036	76,413,775	19,798,570	96,212,345
1901.....	6,736,969	3,367,982	1,860,269	2,867,659	2,945,268	87,747,727	22,463,860	110,211,587
1902.....	7,174,892	3,526,906	3,175,593	3,622,863	3,678,742	98,042,078	24,127,453	122,169,531
1903.....	8,525,369	4,672,028	3,861,343	3,505,329	3,073,856	105,626,369	25,436,052	131,062,421
1904.....	9,187,423	4,107,473	3,629,101	3,023,428	3,669,282	105,864,978	25,158,270	131,023,248
1905.....	10,097,089	5,003,158	4,098,793	3,647,726	3,564,111	121,778,294	27,918,894	149,697,188
1906.....	11,114,967	5,739,460	4,586,538	4,634,898	3,988,394	129,591,838	31,440,884	161,032,722
1907.....	11,482,845	6,026,977	4,250,618	4,551,881	3,000,201	128,798,895	30,143,474	158,942,369
1908.....	11,003,731	4,577,267	3,168,037	3,877,780	2,268,517	108,062,207	25,135,555	133,197,762
1909.....	10,322,324	6,251,625	4,466,708	5,291,963	2,694,821	135,271,772	31,049,441	166,321,213
1910.....	11,428,606	6,976,771	5,110,597	5,240,644	2,743,482	136,331,206	33,784,678	170,115,974
1911.....	11,454,616	6,017,801	5,660,172	5,356,184	2,847,971	127,717,621	34,518,560	162,236,181
1912.....	12,147,677	8,580,426	7,174,148	5,809,405	2,764,783	136,307,111	36,504,164	172,811,275
1913.....	14,872,103	7,733,306	8,620,216	6,109,180	3,018,316	143,296,757	37,992,375	181,289,132
1914.....	14,014,767	6,087,652	8,385,337	5,705,583	3,165,814	129,588,822	35,398,161	164,986,983
1915.....	11,259,349	4,796,062	7,800,938	5,186,055	3,716,944	125,794,844	37,325,388	163,120,232
1916.....	13,577,006	6,466,336	9,942,912	6,475,464	7,094,149	159,042,849	48,217,242	207,260,091

The growth of the clay-working industries in the United States during the last 21 years is shown in this table. The total value of the products ranged from $62,359,991 in 1897 to $207,260,091 in 1916, an increase of $144,900,100, or 232 per cent. The value in 1916 was the greatest ever recorded and was greater by $25,970,959, or 14 per cent, than the previous maximum, in 1913. In the period covered by this table decreases are recorded for seven years—1897, 1904, 1907, 1908, 1911, 1914, and 1915. The greatest decrease was in 1908, $25,744,607, or 16 per cent. The greatest increase was in 1916.

The maximum quantity of common brick was reached in 1906 and the maximum value in 1905. The quantity in 1916 was less than the maximum by 2,632,837,000 brick, or 26 per cent, and the value was less by $12,036,972, or 20 per cent.

Vitrified brick or block reached its maximum quantity in 1909 and its maximum value in 1914. The output in 1916 was less than the maximum by 82,101,000 brick, or 8 per cent, and the value was less by $263,976, or 2 per cent.

Front or face brick reached its maximum quantity and value in 1916. The quantity in that year was greater by 147,094,000 brick, or 17 per cent, than the previous greatest output, in 1915, and the value was greater by $1,752,395, or 18 per cent, than that of the previous greatest value, in 1909.

The use of fancy or ornamental brick continues to decline. The value of this brick in 1916 was the lowest reported, and was less by $654,068 than the maximum in 1896.

Enameled brick reached its maximum value in 1913 and has decreased since that time, the value in 1916 being less by $398,265, or 32 per cent, than the maximum.

The fire-brick industry made the largest gain in value and has increased nearly eightfold in the last 20 years. It attained its maxi-

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mum in 1916 and exceeded the previous greatest value in 1915 by $10,179,007, or nearly 50 per cent.

The value of draintile in 1916 has been exceeded in only one year, 1910, when it was $10,389,822, an excess of only $306,175, or 3 per cent. The value of draintile has increased nearly fourfold in the last 21 years.

The value of sewer pipe has increased more than threefold in the period covered by the table; its maximum value was in 1913. The value of sewer pipe in 1916 was less than the maximum by $1,295,097, or 9 per cent.

Terra cotta reached its maximum value in 1912 and has declined from that time until 1916, when the value was less than the maximum by $2,114,100, or 25 per cent.

Fireproofing reached its maximum value in 1916—nearly six times the value in 1896. Its increase in 1916 over the previous maximum in 1913 was $1,322,696, or 15 per cent.

Tile, other than draintile, reached its maximum value in 1916—four times the value in 1896. The increase in 1916 over the previous maximum in 1913 was $366,284, or 6 per cent.

RANK OF STATES.

Ohio has been the leading State in the value of clay products since the statistics were first compiled by the Geological Survey in 1894. The value of its output has always greatly exceeded that of the second State, Pennsylvania, and in 1916 this excess was $12,837,187, or 40 per cent. New Jersey ranked third. There was no change in the relative rank of the first six States. Missouri rose from ninth in 1915 to seventh in 1916, exchanging places with Iowa. Colorado rose from twenty-third to eighteenth, South Carolina from thirty-fourth to thirty-first, Arkansas from thirty-sixth to thirty-third, and South Dakota from forty-seventh to forty-fourth. The first 10 States reported wares for 1916 valued at $163,746,676, or 79 per cent of the total; for 1915 the same States reported wares valued at $128,961,726, or 79 per cent of the total. The first five States reported wares in 1916 valued at $127,261,332, or 61 per cent of the total, compared with $99,812,010, or 61 per cent of the total in 1915.

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Rank of State, value of output, and percentage of total value of clay products in 1915 and 1916.

State.	1915				1916			
	Rank.	Number of firms reporting sales.	Value.	Percentage of total value.	Rank.	Number of firms reporting sales.	Value.	Percentage of total value.
Ohio	1	524	$36,839,621	22.58	1	500	$44,947,377	21.69
Pennsylvania	2	352	22,726,031	13.93	2	348	32,110,690	15.49
New Jersey	3	149	15,965,418	9.79	3	144	20,814,402	10.04
Illinois	4	247	14,791,038	9.07	4	225	17,633,351	8.51
New York	5	192	9,489,002	5.82	5	186	11,755,012	5.67
Indiana	6	221	7,090,630	4.35	6	199	9,667,313	4.66
Missouri	9	89	5,431,589	3.33	7	83	7,640,995	3.69
West Virginia	8	58	6,284,527	3.85	8	61	7,634,321	3.68
Iowa	7	161	6,743,615	4.13	9	153	[a] 7,379,289	3.56
California	10	82	3,599,375	2.21	10	79	4,163,426	2.01
Kentucky	12	78	2,441,290	1.50	11	69	3,559,257	1.72
Michigan	11	85	2,770,057	1.70	12	78	3,497,770	1.69
Texas	14	93	1,976,890	1.21	13	86	2,837,960	1.37
Kansas	13	43	[a] 2,110,877	1.29	14	48	2,747,803	1.33
Georgia	15	70	1,845,019	1.13	15	64	2,361,982	1.14
Minnesota	16	66	[a] 1,645,913	1.01	16	55	[a] 2,064,362	1.00
Tennessee	19	69	1,548,220	.95	17	66	1,983,957	.96
Colorado	23	58	1,265,105	.78	18	49	1,930,039	.93
Massachusetts	17	59	1,583,604	.97	19	56	1,892,558	.91
Maryland	18	43	1,576,456	.97	20	43	1,825,870	.88
Connecticut and Rhode Island	20	38	[a] 1,518,773	.93	21	37	[a] 1,762,653	.85
Virginia	22	58	[a] 1,447,802	.89	22	56	[a] 1,676,723	.81
Washington	21	43	[a] 1,454,436	.89	23	40	[a] 1,589,574	.77
North Carolina	25	137	1,089,935	.67	24	125	1,551,436	.75
Alabama	24	65	1,193,022	.73	25	57	1,520,301	.73
Oklahoma	26	29	996,451	.61	26	27	1,410,657	.68
Nebraska	28	44	[a] 776,899	.48	27	37	[a] 943,553	.46
Wisconsin	27	75	910,558	.56	28	69	[a] 905,910	.44
Utah	29	29	[a] 699,962	.43	29	24	[a] 885,357	.43
Montana	30	22	[a] 524,575	.32	30	22	[a] 717,551	.35
South Carolina	34	33	379,133	.23	31	36	607,151	.29
Maine	31	33	[a] 488,079	.30	32	34	[a] 546,725	.26
Arkansas	36	33	343,967	.21	33	31	[a] 521,569	.25
Mississippi	35	48	367,619	.22	34	38	520,618	.25
New Hampshire	32	19	[a] 484,404	.30	35	19	[a] 473,434	.23
Louisiana	33	37	[a] 385,002	.24	36	27	[a] 360,855	.17
Oregon	37	41	[a] 341,243	.21	37	37	[a] 299,993	.14
North Dakota	40	11	189,355	.12	38	8	264,457	.13
New Mexico	38	7	240,847	.15	39	6	257,561	.12
Florida	39	16	203,414	.12	40	14	226,362	.11
Idaho and Nevada	43	22	128,382	.08	41	21	212,451	.10
Delaware	41	14	145,694	.09	42	14	187,388	.09
District of Columbia	42	7	[a] 131,134	.08	43	5	[a] 129,394	.06
South Dakota	47	5	36,342	.02	44	5	115,474	.06
Arizona	44	11	97,208	.06	45	10	106,149	.05
Vermont	45	5	71,642	.04	46	6	94,779	.05
Wyoming	46	10	57,021	03	47	9	90,199	.04
Porto Rico	48	5	[a] 4,193	.00	48	6	[a] 5,612	.00
Undistributed	.....	.....	[b] 687,923	.42	.....	.....	[b] 827,971	.40
	.....	3,636	163,120,232	100.00	.....	3,412	207,260,091	100.00

[a] Exclusive of pottery, the value of which is included under "Undistributed."
[b] Undistributed pottery products.

BRICK AND TILE.

PRODUCTION.

PRODUCTION BY STATES.

The following tables show the output and value of the building brick and other structural products of clay, and of the fire brick, paving brick, and other clay products used in engineering work, the

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rank of the State in these products, and the percentage of the total value of each State in 1915 and 1916:

Brick and tile products in the United States in 1915.

Rank.	State.	Common brick.			Vitrified brick or block.		
		Quantity (thousands).	Value.	Average price per thousand.	Quantity (thousands).	Value.	Average price per thousand.
24	Alabama	70,681	$382,092	$5.41	29,018	$374,387	$12.90
44	Arizona	10,169	85,085	8.36	.....	.....	.....
37	Arkansas	45,001	267,477	5.94	(a)	(a)	12.00
9	California	160,452	981,888	6.12	3,182	66,784	20.99
23	Colorado	35,729	233,089	6.52	(a)	(a)	11.59
17	Connecticut and Rhode Island	211,490	1,382,087	6.53	(a)	(a)	12.66
41	Delaware	17,139	133,733	7.80	.....	.....	.....
42	District of Columbia	14,767	96,150	6.51	.....	.....	.....
39	Florida	31,019	182,149	5.87	.....	.....	.....
14	Georgia	158,465	801,202	5.06	17,193	166,086	9.66
43	Idaho and Nevada	11,933	102,341	8.58	.....	.....	.....
3	Illinois	1,066,057	6,870,990	6.45	142,689	1,796,350	12.59
7	Indiana	137,964	802,224	5.81	35,237	466,873	13.25
6	Iowa	125,752	898,851	7.15	20,573	300,785	14.62
12	Kansas	110,839	499,434	4.51	47,511	608,599	12.81
10	Kentucky	74,807	479,506	6.41	(a)	(a)	10.85
33	Louisiana	62,332	354,023	5.68	.....	.....	.....
31	Maine	35,230	265,777	7.54	(a)	(a)	21.72
22	Maryland	115,814	834,129	7.20	10,439	181,488	17.38
21	Massachusetts	144,520	1,026,179	7.10	.....	.....	.....
11	Michigan	277,399	1,461,188	5.27	4,420	62,238	14.08
16	Minnesota	107,473	675,146	6.28	(a)	(a)	14.18
35	Mississippi	58,705	304,937	5.19	.....	.....	.....
8	Missouri	135,044	898,446	6.65	(a)	(a)	14.62
30	Montana	27,422	277,812	10.13	(a)	(a)	22.01
28	Nebraska	85,753	552,676	6.44	561	8,323	14.84
32	New Hampshire	60,818	484,464	7.97	.....	.....	.....
4	New Jersey	354,104	2,099,654	5.93	.....	.....	.....
38	New Mexico	14,755	108,191	7.33	(a)	(a)	12.00
5	New York	980,580	5,157,677	5.26	24,154	384,458	15.92
25	North Carolina	140,257	862,391	6.15	.....	.....	.....
40	North Dakota	14,620	110,988	7.59	(a)	(a)	11.32
1	Ohio	422,292	2,604,602	6.17	333,288	4,017,758	12.05
26	Oklahoma	64,953	327,208	5.04	16,537	198,387	12.00
36	Oregon	17,723	137,881	7.78	(a)	(a)	9.00
2	Pennsylvania	677,291	4,515,296	6.67	124,354	1,638,518	13.18
48	Porto Rico	507	4,193	8.27	.....	.....	.....
34	South Carolina	60,421	352,389	5.83	.....	.....	.....
47	South Dakota	4,087	33,342	8.16	.....	.....	.....
20	Tennessee	113,004	655,094	5.80	(a)	(a)	14.47
13	Texas	147,469	828,386	5.62	(a)	(a)	15.45
29	Utah	32,785	239,212	7.30	(a)	(a)	29.31
45	Vermont	6,522	41,570	6.37	.....	.....	.....
19	Virginia	186,649	1,215,559	6.51	.....	.....	.....
18	Washington	43,279	285,423	6.59	14,861	265,691	17.88
15	West Virginia	64,649	445,843	6.90	69,474	841,067	12.11
27	Wisconsin	107,268	735,028	6.85	(a)	(a)	20.12
46	Wyoming	5,110	52,290	10.23	.....	.....	.....
	Undistributed b	.....	.....	.....	59,844	853,107	.....
		6,851,099	42,145,292	6.15	c953,335	c12,230,899	12.83
	Percentage of brick and tile products	.....	33.50	.....	.....	9.72	.....
	Percentage of total clay products	.....	25.84	.....	.....	7.50	.....

a Included in "Undistributed."
b Includes all products made by less than 3 producers in 1 State.
c In the total quantity and total value of vitrified brick are included, respectively, 824,359,000 vitrified brick or block sold for paving, valued at $11,114,427, and 128,976,000 vitrified brick or block sold for other uses, valued at $1,116,472.

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Brick and tile products in the United States in 1915—Continued.

Rank.	State.	Front brick.			Fancy or ornamental brick (value).	Drain tile (value).	Sewer pipe (value).	Architectural terra cotta (value).	Fire proofing (value).
		Quantity (thousands).	Value.	Average price per thousand.					
24	Alabama	5,815	$58,212	$10.01	.....	$9,330	(a)	.....	$62,114
44	Arizona	(a)	(a)	19.87	.....	.....	.....	.....	.....
37	Arkansas	1,973	32,572	16.51	.....	3,969	.....	.....	.....
9	California	10,348	221,791	21.43	(a)	33,222	$707,480	$308,930	174,739
23	Colorado	9,538	102,925	10.79	$17,699	49,125	(a)	(a)	22,560
17	Conecticut and Rhode Island	(a)	(a)	36.17	(a)	.....	.....	.....	(a)
41	Delaware	.....	.....	.....	.....	(a)	.....	.....	.....
42	District of Columbia	.....	.....	.....	.....	(a)	(a)	.....	(a)
39	Florida	.....	.....	.....	.....	(a)	.....	.....	(a)
14	Georgia	8,483	78,826	9.29	.....	(a)	567,118	(a)	(a)
43	Idaho and Nevada	(a)	(a)	15.00	.....	.....	.....	.....	(a)
3	Illinois	58,107	635,686	10.94	(a)	991,709	569,536	1,289,848	492,138
7	Indiana	83,610	897,242	10.73	(a)	1,253,805	563,144	(a)	651,714
6	Iowa	11,916	153,324	12.87	.....	3,802,599	448,721	.....	1,008,457
12	Kansas	31,429	292,584	9.31	.....	63,813	(a)	(a)	125,234
10	Kentucky	3,252	33,062	10.17	.....	64,948	(a)	.....	32,311
33	Louisiana	(a)	(a)	10.73	.....	.....	.....	.....	.....
31	Maine	(a)	(a)	8.00	.....	(a)	(a)	.....	.....
22	Maryland	(a)	(a)	11.39	(a)	2,271	.....	(a)	(a)
21	Massachusetts	(a)	(a)	20.00	.....	.....	.....	.....	(a)
11	Michigan	3,619	40,822	11.28	.....	305,156	(a)	.....	10,850
16	Minnesota	17,157	205,519	11.98	.....	255,347	(a)	.....	125,595
35	Mississippi	618	6,715	10.87	.....	36,077	.....	.....	.....
8	Missouri	26,040	335,767	12.89	16,360	152,445	1,012,337	259,662	134,690
30	Montana	837	15,496	18.51	.....	(a)	(a)	.....	(a)
28	Nebraska	7,582	116,650	15.39	(a)	9,599	.....	.....	79,973
32	New Hampshire	.....	.....	.....	.....	.....	.....	.....	.....
4	New Jersey	25,698	375,431	14.61	(a)	41,331	(a)	1,430,968	1,389,120
38	New Mexico	5,052	81,621	16.16	.....	.....	.....	.....	30,212
5	New York	6,272	70,142	11.18	(a)	61,593	(a)	647,816	148,946
25	North Carolina	(a)	(a)	10.00	.....	14,600	(a)	.....	(a)
40	North Dakota	(a)	(a)	15.37	(a)	.....	.....	.....	(a)
1	Ohio	185,605	1,925,096	10.37	20,844	1,430,385	3,719,790	.....	2,172,701
26	Oklahoma	16,899	166,454	9.85	.....	.....	.....	.....	.....
36	Oregon	2,821	58,215	20.64	.....	46,328	(a)	.....	40,228
2	Pennsylvania	244,781	2,631,795	10.75	17,327	12,200	1,003,913	(a)	486,164
48	Porte Rico	.....	.....	.....	.....	.....	.....	.....	.....
34	South Carolina	(a)	(a)	14.50	.....	(a)	.....	.....	.....
47	South Dakota	(a)	(a)	15.00	.....	.....	.....	.....	.....
20	Tennessee	17,190	139,697	8.13	(a)	47,914	(a)	.....	(a)
13	Texas	18,413	225,034	12.22	.....	10,846	(a)	.....	152,832
29	Utah	12,489	126,585	10.14	.....	22,417	(a)	.....	27,792
45	Vermont	.....	.....	.....	.....	(a)	.....	.....	.....
19	Virginia	15,705	192,443	12.25	(a)	7,450	(a)	.....	(a)
18	Washington	4,246	67,740	15.95	.....	33,558	318,397	234,377	192,263
15	West Virginia	1,271	15,606	12.28	.....	6,189	(a)	.....	(a)
27	Wisconsin	8,624	95,224	11.04	.....	67,766	.....	.....	(a)
46	Wyoming	271	4,368	16.12	.....	.....	.....	.....	.....
	Undistributed [b]	10,004	132,892	.....	37,195	43,272	2,348,913	624,461	240,310
		855,668	9,535,536	11.14	[c]945,233	8,879,264	11,259,349	4,796,062	7,800,938
	Percentage of brick and tile products	.....	7.58	.....	.75	7.06	8.95	3.81	6.20
	Percentage of total clay products	.....	5.85	.....	.58	5.44	6.90	2.94	4.78

[a] Included in "Undistributed."
[b] Includes all products made by less than 3 producers in 1 State.
[c] Includes enameled brick, valued at $835,808, made in California, Colorado, Illinois, Maryland, Missouri, Nebraska, and New Jersey.

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Brick and tile products in the United States in 1915—Continued.

Rank.	State.	Tile, not drain (value).	Stove lining (value).	Fire brick. Quantity (thousands).	Fire brick. Value.	Fire brick. Average price per thousand.	Miscellaneous,[a] value.	Total value.	Percentage of total value.
24	Alabama	.....	(b)	7,330	$145,535	$19.85	$4,913	$1,177,725	0.94
44	Arizona	.....	.....	.....	.....	.....	.....	97,208	.08
37	Arkansas	.....	.....	(b)	(b)	13.05	.....	323,682	.26
9	California	$164,524	(b)	16,821	421,505	25.06	83,089	3,231,281	2.57
23	Colorado	9,624	.....	10,031	256,059	25.53	149,727	1,202,220	.96
17	Connecticut and Rhode Island	(b)	(b)	(b)	(b)	22.00	.....	1,518,773	1.21
41	Delaware	.....	.....	.....	.....	.....	.....	145,694	.12
42	District of Columbia	.....	.....	.....	.....	.....	.....	131,134	.10
39	Florida	.....	.....	.....	.....	.....	.....	203,414	.16
14	Georgia	.....	.....	3,733	54,000	14.47	7,542	1,826,842	1.45
43	Idaho and Nevada	.....	.....	(b)	(b)	22.50	.....	128,382	.10
3	Illinois	(b)	(b)	18,704	320,740	17.15	329,549	13,843,046	11.00
7	Indiana	(b)	.....	5,378	107,539	20.00	346,834	5,892,596	4.68
6	Iowa	(b)	(b)	(b)	(b)	24.42	41,145	6,738,190	5.36
12	Kansas	(b)	.....	.....	.....	.....	240,104	2,110,877	1.68
10	Kentucky	205,184	.....	77,170	1,325,804	17.18	17,932	2,332,451	1.85
33	Louisiana	.....	.....	.....	.....	.....	18,172	385,002	.31
31	Maine	.....	.....	(b)	(b)	31.08	1,992	488,079	.39
22	Maryland	.....	$18,677	11,808	226,090	19.15	(b)	1,369,738	1.09
21	Massachusetts	95,929	161,795	1,690	60,735	35.94	2,350	1,399,371	1.11
11	Michigan	(b)	.....	(b)	(b)	8.00	49,755	2,248,068	1.79
16	Minnesota	.....	.....	(b)	(b)	40.00	.....	1,645,913	1.31
35	Mississippi	.....	.....	.....	.....	.....	4,200	351,929	.28
8	Missouri	(b)	(b)	99,945	1,922,738	19.24	82,877	5,428,403	4.31
30	Montana	.....	.....	837	34,992	41.81	41,799	524,575	.42
28	Nebraska	.....	.....	.....	.....	.....	1,348	776,899	.62
32	New Hampshire	.....	.....	.....	.....	.....	.....	484,464	.38
4	New Jersey	995,097	(b)	36,403	899,613	24.71	264,299	7,916,080	6.29
38	New Mexico	.....	.....	(b)	(b)	15.20	.....	240,847	.19
5	New York	75,685	65,064	8,614	340,151	39.49	40,040	7,047,262	5.60
25	North Carolina	.....	.....	(b)	(b)	15.00	.....	1,078,541	.86
40	North Dakota	.....	.....	(b)	(b)	25.62	.....	189,355	.15
1	Ohio	2,334,375	(b)	123,179	1,996,792	16.21	548,108	20,909,842	16.62
26	Oklahoma	.....	.....	236	21,540	91.27	282,862	996,451	.79
36	Oregon	(b)	.....	60	2,030	33.83	.....	341,243	.27
2	Pennsylvania	299,907	104,995	379,042	7,177,629	18.94	793,405	20,898,282	16.61
48	Porto Rico	.....	.....	.....	.....	.....	.....	4,193	.00
34	South Carolina	.....	.....	(b)	(b)	15.00	.....	370,152	.29
47	South Dakota	.....	.....	.....	.....	.....	.....	36,342	.03
20	Tennessee	.....	.....	(b)	(b)	13.50	140,515	1,441,831	1.15
13	Texas	.....	.....	5,054	83,236	16.47	91,919	1,911,501	1.52
29	Utah	.....	(b)	(b)	(b)	31.90	5,715	699,962	.56
45	Vermont	.....	(b)	.....	.....	.....	.....	71,642	.06
19	Virginia	.....	.....	(b)	(b)	13.93	.....	1,447,802	1.15
18	Washington	.....	.....	1,569	45,414	28.94	11,573	1,454,436	1.16
15	West Virginia	181,495	.....	16,807	143,301	8.53	106,579	1,773,904	1.41
27	Wisconsin	.....	(b)	.....	.....	.....	.....	902,199	.72
46	Wyoming	.....	.....	(b)	(b)	18.00	345	57,021	.04
	Undistributed[c]	824,235	108,810	9,328	214,619	.....	8,256	(d)	.....
		[e]5,186,055	459,341	[f]963,983	[f]18,839,931	19.54	3,716,944	125,794,844	100.00
	Percentage of brick and tile products	4.12	.37	.....	14.98	.....	2.96	100.00	.....
	Percentage of total clay products	3.18	.28	.....	11.55	.....	2.28	77.12	.....

[a] Including adobes, assay supplies, burnt-clay ballast, charcoal furnaces, chemical brick and tile, chimney flues, pipe, thimbles and tops, condensers, conduits, crucibles, flue lining, gas logs, glasshouse pots and glasshouse supplies, grave and lot markers, muffles, sewer and chimney radial brick and block, retorts, scorifiers, sewer brick and blocks, sundials, vases, and wall coping.

[b] Included in "Undistributed."

[c] Includes all products made by less than 3 producers in 1 State.

[d] The total of "Undistributed" is distributed among the States to which it belongs, in order that they may be fully represented in the totals.

[e] Includes the following values: Roofing tile, $891,150; floor tile, $912,180; ceramic mosaic tile, $1,185,787; faience tile, $635,073; wall tile, $1,561,865.

[f] In the total quantity and total value of fire brick are included, respectively, 130,244,000 silica brick, valued at $3,039,869, of which 92,348,000, valued at $1,911,321, were produced by Pennsylvania; and the remainder, 37,896,000, valued at $1,128,548, by Alabama, Colorado, Illinois, Indiana, Missouri, Montana, New Jersey, Ohio, and Utah.

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Brick and tile products in the United States in 1916.

Rank.	State.	Common brick.			Vitrified brick or block.		
		Quantity (thousands).	Value.	Average price per thousand.	Quantity (thousands).	Value.	Average price per thousand.
25	Alabama	85,655	$497,446	$5.81	(a)	(a)	$12.38
45	Arizona	11,039	93,649	8.48			
33	Arkansas	65,419	418,034	6.39			
9	California	168,826	1,107,940	6.56	6,240	$126,168	20.22
17	Colorado	50,281	340,846	6.78	1,869	21,653	11.59
18	Connecticut and Rhode Island	184,098	1,640,349	8.91	(a)	(a)	18.53
42	Delaware	20,321	177,588	8.74			
43	District of Columbia	12,900	86,260	6.69			
40	Florida	31,029	188,357	6.07			
14	Georgia	208,781	1,050,473	5.03	15,652	173,505	11.09
41	Idaho and Nevada	19,725	168,076	8.52			
3	Illinois	1,182,473	6,738,152	5.70	175,989	2,465,179	14.01
6	Indiana	166,954	963,932	5.77	55,490	758,943	13.68
8	Iowa	132,676	947,247	7.14	24,265	393,038	16.20
12	Kansas	114,880	596,271	5.19	48,704	628,638	12.91
10	Kentucky	70,610	464,775	6.58	(a)	(a)	11.70
36	Louisiana	59,695	333,573	5.59			
22	Maine	35,431	289,171	8.16	(a)	(a)	25.34
23	Maryland	119,650	871,866	7.29	(a)	(a)	14.55
21	Massachusetts	140,420	1,207,777	8.60			
13	Michigan	279,175	1,856,587	6.65	5,539	80,915	14.61
15	Minnesota	118,090	772,696	6.54	(a)	(a)	8.87
34	Mississippi	70,123	453,185	6.46			
7	Missouri	126,658	896,201	7.08	(a)	(a)	13.83
30	Montana	44,498	481,546	10.82	(a)	(a)	24.03
27	Nebraska	102,729	699,837	6.81	(a)	(a)	12.68
35	New Hampshire	51,852	473,434	9.13			
4	New Jersey	328,419	2,366,614	7.21			
30	New Mexico	12,375	96,612	7.81	(a)	(a)	12.00
5	New York	977,085	6,433,266	6.58	18,788	248,932	13.25
24	North Carolina	193,264	1,234,926	6.39			
38	North Dakota	19,155	174,289	9.10			
2	Ohio	437,334	3,082,099	7.05	295,048	3,522,695	11.94
26	Oklahoma	106,378	594,082	5.58	(a)	(a)	11.32
37	Oregon	15,792	128,289	8.12	(a)	(a)	9.04
1	Pennsylvania	688,096	5,200,910	7.56	118,664	1,495,645	12.60
45	Porto Rico	616	5,612	9.11			
31	South Carolina	100,349	589,016	5.87			
44	South Dakota	10,701	103,474	9.67			
19	Tennessee	161,761	1,004,234	6.21	(a)	(a)	15.23
11	Texas	203,013	1,224,919	6.03	(a)	(a)	11.82
29	Utah	40,269	324,966	8.07	(a)	(a)	16.62
46	Vermont	9,651	64,779	6.71			
20	Virginia	204,808	1,397,436	6.82			
22	Washington	45,163	309,130	6.84	20,218	322,182	15.94
16	West Virginia	59,993	420,955	7.02	46,416	579,679	12.49
28	Wisconsin	98,060	699,819	7.14			
47	Wyoming	7,932	86,716	10.93			
	Undistributed b				108,671	1,419,718	
		7,394,202	49,357,411	6.68	c 941,553	c 12,236,890	13.00
	Percentage of brick and tile products		31.03			7.69	
	Percentage of total clay products		23.82			5.90	

a Included in "Undistributed."
b Includes all products made by less than 3 producers in 1 State.
c In the total quantity and total value of vitrified brick are included, respectively, 760,672,000 vitrified brick or block sold for paving, valued at $10,614,797, and 180,881,000 vitrified brick or block, sold for other uses, valued at $1,622,093.

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Brick and tile products in the United States in 1916—Continued.

Rank.	State.	Front brick.			Fancy or ornamental brick (value).	Draintile (value).	Sewer pipe (value).	Architectural terra cotta (value).	Fireproofing (value).
		Quantity (thousands).	Value.	Average price per thousand.					
25	Alabama	6,968	$77,470	$11.12	.....	(a)	(a)	.....	$80,523
45	Arizona	(a)	(a)	25.00	.....	.....	.....	.....	.....
33	Arkansas	1,880	24,980	13.29	.....	(a)	.....	.....	.....
9	California	9,035	208,255	23.05	.....	$44,292	$772,295	$341,671	165,698
17	Colorado	16,314	195,976	12.01	(a)	70,015	(a)	(a)	33,840
18	Connecticut and Rhode Island	(a)	(a)	16.03	(a)	.....	.....	.....	(a)
42	Delaware	.....	.....	.....	.....	(a)	.....	.....	.....
43	District of Columbia	.....	.....	.....	.....	(a)	(a)	.....	(a)
40	Florida	.....	.....	.....	.....	(a)	.....	.....	(a)
14	Georgia	10,670	105,130	9.85	.....	7,758	691,628	(a)	44,350
41	Idaho and Nevada	(a)	(a)	14.78	.....	.....	.....	.....	(a)
3	Illinois	74,652	810,440	10.86	(a)	1,200,465	768,410	1,980,781	769,929
6	Indiana	116,860	1,192,076	10.20	.....	1,452,719	666,792	(a)	799,260
8	Iowa	22,112	283,559	12.82	.....	3,996,163	494,428	.....	1,141,291
12	Kansas	40,433	380,332	9.41	(a)	84,224	(a)	(a)	183,109
10	Kentucky	2,181	22,342	10.24	.....	70,661	(a)	.....	57,753
36	Louisiana	(a)	(a)	10.90	.....	(a)	.....	.....	(a)
32	Maine	(a)	(a)	9.50	.....	(a)	(a)	.....	.....
23	Maryland	(a)	(a)	16.08	(a)	2,040	.....	(a)	42,629
21	Massachusetts	(a)	(a)	24.00	.....	.....	.....	.....	(a)
13	Michigan	.....	.....	.....	(a)	548,795	(a)	.....	2,492
15	Minnesota	19,014	243,246	12.79	.....	422,809	(a)	.....	153,486
34	Mississippi	1,090	13,702	12.57	.....	38,771	.....	.....	.....
7	Missouri	37,325	481,406	12.90	(a)	197,150	1,308,977	(a)	153,596
30	Montana	3,700	60,261	16.29	.....	.....	(a)	.....	28,439
27	Nebraska	4,655	78,390	16.84	.....	16,172	.....	.....	124,411
35	New Hampshire	.....	.....	.....	.....	.....	.....	.....	.....
4	New Jersey	23,174	462,490	19.96	(a)	30,542	(a)	1,818,052	1,830,949
39	New Mexico	7,642	98,267	12.86	(a)	(a)	.....	.....	(a)
5	New York	5,857	64,004	10.93	.....	63,756	(a)	714,041	174,786
24	North Carolina	(a)	(a)	10.28	.....	18,000	(a)	.....	(a)
38	North Dakota	(a)	(a)	16.08	(a)	.....	.....	.....	(a)
2	Ohio	209,584	2,161,719	10.31	$19,049	1,470,054	5,132,810	.....	2,816,535
26	Oklahoma	4,397	40,881	9.30	.....	.....	.....	.....	.....
37	Oregon	3,446	57,826	16.78	.....	53,041	(a)	.....	50,741
1	Pennsylvania	277,612	3,076,024	11.08	18,562	13,002	1,207,016	473,634	664,293
48	Porto Rico	.....	.....	.....	.....	.....	.....	.....	.....
31	South Carolina	(a)	(a)	14.31	.....	(a)	.....	.....	.....
44	South Dakota	(a)	(a)	15.00	.....	.....	.....	.....	.....
19	Tennessee	6,716	87,253	12.99	13,884	45,162	(a)	.....	16,424
11	Texas	28,481	358,355	12.58	.....	13,024	(a)	.....	253,529
29	Utah	13,883	170,003	12.25	.....	(b)	(a)	.....	77,512
46	Vermont	.....	.....	.....	.....	.....	.....	.....	.....
20	Virginia	18,441	232,135	12.59	(a)	7,125	(a)	.....	.....
22	Washington	4,425	70,509	15.93	(a)	37,138	347,388	275,693	125,033
16	West Virginia	4,194	44,397	10.59	.....	7,285	.....	.....	(a)
28	Wisconsin	12,482	133,445	10.69	.....	69,404	.....	.....	(a)
47	Wyoming	(a)	(a)	14.88	.....	.....	.....	.....	.....
	Undistributed b	15,539	229,741	.....	57,577	104,080	2,187,262	862,464	152,904
		1,002,762	11,464,614	11.43	c936,515	10,083,647	13,577,006	6,466,336	9,942,902
	Percentage of brick and tile products	.....	7.21	.....	.59	6.34	8.54	4.07	6.25
	Percentage of total clay products	.....	5.53	.....	.45	4.87	6.55	3.12	4.80

a Included in "Undistributed."
b Includes all products made by less than 3 producers in 1 State.
c Includes enameled brick valued at $827,443, made in California, Colorado, Illinois, Maryland, Missouri, New Jersey, and Utah.

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Brick and tile products in the United States in 1916—Continued.

Rank.	State or Territory.	Tile, not drain (value).	Stove lining (value).	Fire brick. Quantity (thousands).	Fire brick. Value.	Fire brick. Average price per thousand.	Miscellaneous a (value).	Total value.	Per centage of total value.
25	Alabama	.....	(b)	13,379	$278,749	$20.83	$803	$1,497,496	0.94
45	Arizona	.....	.....	.....	.....	.....	.....	106,149	.07
33	Arkansas	.....	.....	1,435	19,281	13.44	58,356	521,569	.33
9	California	$197,779	(b)	20,327	508,900	25.04	103,887	3,645,629	2.29
17	Colorado	16,735	.....	18,602	412,511	22.18	227,145	1,818,470	1.14
18	Connecticut and Rhode Island	(b)	(b)	(b)	(b)	27.00	.....	1,762,653	1.11
42	Delaware	.....	.....	.....	.....	.....	.....	187,388	.12
43	District of Columbia	.....	.....	.....	.....	.....	4,268	129,394	.08
40	Florida	.....	.....	.....	.....	.....	.....	226,362	.14
14	Georgia	.....	$14,833	(b)	(b)	14.65	12,909	2,348,781	1.48
41	Idaho and Nevada	.....	.....	(b)	(b)	22.16	.....	212,451	.13
3	Illinois	(b)	(b)	26,880	523,442	19.47	451,150	16,507,845	10.38
6	Indiana	680,820	.....	31,092	872,218	27.52	611,200	8,032,960	5.05
8	Iowa	(b)	.....	.....	.....	.....	69,052	7,379,289	4.64
12	Kansas	(b)	(b)	(b)	(b)	35.00	563,789	2,747,803	1.73
10	Kentucky	295,815	.....	114,945	2,323,606	20.21	15,315	3,438,146	2.16
36	Louisiana	.....	.....	.....	.....	.....	13,350	360,855	.23
32	Maine	.....	.....	(b)	(b)	39.13	.....	546,725	.34
23	Maryland	.....	22,158	17,724	412,832	23.29	8,750	1,548,295	.97
21	Massachusetts	158,387	180,482	2,014	80,168	39.81	450	1,661,737	1.04
13	Michigan	(b)	.....	.....	.....	.....	77,620	2,705,054	1.70
15	Minnesota	.....	.....	(b)	(b)	45.00	97,901	2,064,362	1.30
34	Mississippi	.....	.....	(b)	(b)	20.00	2,940	508,698	.32
7	Missouri	(b)	(b)	126,257	3,006,841	23.82	349,522	7,634,559	4.80
30	Montana	.....	.....	866	36,768	42.46	21,121	717,551	.45
27	Nebraska	.....	.....	.....	.....	.....	19,200	943,553	.59
35	New Hampshire	.....	.....	.....	.....	.....	.....	473,434	.30
4	New Jersey	1,298,392	(b)	37,891	1,162,794	30.69	335,253	9,749,524	6.13
39	New Mexico	.....	.....	3,115	42,452	13.63	.....	257,561	.16
5	New York	86,112	80,605	9,955	417,805	41.97	75,533	8,410,340	5.29
24	North Carolina	.....	.....	.....	.....	.....	(b)	1,541,576	.97
38	North Dakota	.....	.....	(b)	(b)	26.69	.....	264,457	.17
2	Ohio	2,615,854	(b)	135,557	3,337,470	17.99	1,106,928	25,506,344	16.04
26	Oklahoma	.....	.....	(b)	(b)	93.36	593,589	1,410,657	.89
37	Oregon	.....	.....	(b)	(b)	27.74	39	299,993	.19
1	Pennsylvania	506,805	106,344	515,530	11,009,646	21.36	1,665,974	29,630,563	18.63
48	Porto Rico	.....	.....	.....	.....	.....	.....	5,612	.....
31	South Carolina	.....	.....	.....	.....	.....	.....	598,431	.38
44	South Dakota	.....	.....	.....	.....	.....	.....	115,474	.07
19	Tennessee	(b)	.....	(b)	(b)	14.00	(b)	1,679,319	1.06
11	Texas	.....	(b)	3,371	53,135	15.76	227,700	2,749,780	1.73
29	Utah	.....	.....	(b)	(b)	32.22	6,864	885,357	.56
46	Vermont	.....	(b)	.....	.....	.....	.....	94,779	.06
20	Virginia	.....	.....	(b)	(b)	16.83	.....	1,676,723	1.05
22	Washington	.....	(b)	4,009	94,992	23.69	5,357	1,589,574	1.00
16	West Virginia	239,601	.....	18,266	209,625	11.48	308,401	1,853,468	1.16
28	Wisconsin	.....	(b)	.....	.....	.....	112	905,910	.57
47	Wyoming	.....	.....	.....	.....	.....	.....	90,199	.06
	Undistributed c	379,164	195,354	14,777	352,284	.....	59,671	(d)	.....
		e6,475,464	601,776	f1,376,923	f30,806,129	22.37	7,094,149	159,042,849	100.00
	Percentage of brick and tile products	4.07	.38	.....	19.37	.....	4.46	100.00	.....
	Percentage of total clay products	3.13	.29	.....	14.86	.....	3.42	76.74	.....

a Including adobes, assay supplies, bituminized blocks, burnt-clay ballast, charcoal furnaces, chemical brick and tile, chimney crocks, pipe and tops, clay pigeons, condensers, conduits, crucibles, floral terra cotta, flue lining, flux bricks, gas logs, glasshouse pots and glasshouse supplies, grave and lot markers, ironing furnaces, muffles, radial brick and block, retorts, scorifiers, segment blocks, sewer blocks, and wall coping.

b Included in "Undistributed."

c Includes all products made by less than 3 producers in 1 State.

d The total of "Undistributed" is distributed among the States to which it belongs, in order that they may be fully represented in the totals.

e Including the following values: Roofing tile, $914,240; floor tile, $1,438,231; ceramic mosaic tile, $1,308,861; faience tile, $814,077; wall tile, $2,000,055.

f In the total quantity and total value of fire brick are included, respectively, 210,331,000 silica brick, valued at $5,650,610, of which 166,291,000, valued at $4,190,708, were produced by Pennsylvania, and the remainder, 44,040,000, valued at $1,459,902, by Alabama, Colorado, Illinois, Missouri, Montana, New Jersey, Ohio, Utah, and Virginia.

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Brick and tile products, as classified in this report, were reported from every State, the District of Columbia, and Porto Rico. Only two States, Illinois and Missouri, reported every variety of wares classified under this head, and Colorado, New Jersey, and Pennsylvania reported all but one.

The increase in the value of brick and tile in 1916 compared with 1915 was $33,248,005, or more than 26 per cent. Pennsylvania was the leading State in 1916, displacing Ohio, which was second. There was an increase of $8,732,281, or 42 per cent, in the value of Pennsylvania's brick and tile products in 1916, and of $4,596,502, or 22 per cent, in those of Ohio. Illinois was third, as for several years, with an increase of $2,664,799; New Jersey was fourth, with an increase of $1,833,444; and New York was fifth, with an increase of $1,363,078. Indiana was sixth, displacing Iowa; Missouri was seventh, Iowa eighth, California ninth, and Kentucky tenth, as in 1915.

The only clay product reported from every State and the District of Columbia and Porto Rico is common brick. This product, the value of which constituted nearly 24 per cent of the value of all clay products, and more than 31 per cent of brick and tile products in 1916, increased 543,103,000 brick, or 8 per cent, compared with 1915. In 1915 there was a decrease of 295,472,000 brick, or 4 per cent, compared with 1914. Thirty-four States reported increase in quantity and value of common brick marketed in 1916, compared with 1915; nine States—District of Columbia, Kentucky, Louisiana, Missouri, New Hampshire, New Mexico, Oregon, West Virginia, and Wisconsin—reported decrease in quantity and value in 1916; four States—Connecticut and Rhode Island (taken together), Massachusetts, New Jersey, and New York—reported decrease in quantity and increase in value; and Illinois reported increase in quantity and decrease in value. Fourteen States reported common brick marketed to the value of $1,000,000 or more.

Illinois was the largest producer of common brick in 1916, as for several years, followed by New York, Pennsylvania, Ohio, and New Jersey in the order named. Of the output of Illinois, 833,164,000 brick, or 70 per cent, was from Cook County, and of the output of New York, 702, 596, 000 brick, or 72 per cent, was from the Hudson River region. The average price per thousand in 1916, which ranged from $5.03 in Georgia to $10.93 in Wyoming, decreased in only six States, and the decrease in these, except in Illinois, was only a few cents. In Illinois the decrease was 75 cents. In nine States the average price per thousand brick increased more than $1—in Connecticut and Rhode Island (taken together) $2.38; Massachusetts, $1.50; Michigan, $1.38; Mississippi, $1.27; New Hampshire, $1.16; New Jersey, $1.28; New York, $1.32; North Dakota, $1.51; and South Dakota, $1.51. The average price per thousand for the entire country increased 53 cents, compared with 1915.

Vitrified brick or block, the fourth brick and tile product in value in 1916, was reported from 28 States, a decrease of 3—Arkansas, North Dakota, and Wisconsin. Ohio, as for many years, was the leading State, and reported 31 per cent of the total quantity and 29 per cent of the total value in 1916. Illinois ranked second, reporting 19 per cent of the output, and 20 per cent of the value; Pennsylvania was third, with 13 per cent of the quantity and 12 per cent of the value; Indiana was fourth, with 6 per cent of the quantity and value;

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and Kansas was fifth, with 5 per cent. These five States reported for 1916, 74 per cent of the total quantity and 72 per cent of the total value. Of the output marketed in 1916, 760,672,000 vitrified brick or block, or 81 per cent, was sold for paving, and 180,881,000 brick or block, or 19 per cent, was sold for other purposes. The average price per thousand of the vitrified brick sold for paving was $13.95; sold for other purposes, $8.97, an increase of 47 cents and 31 cents, respectively. The quantity of vitrified brick or block marketed in 1916 was 941,553,000, a decrease of 11,782,000, but owing to slightly higher prices the value showed a small increase. The average price per thousand for vitrified brick or block ranged in the more important States from $11.09 in Georgia to $20.22 in California.

The manufacture of front brick is the most widely distributed branch of the clay-working industries, except that of common brick, and in 1916 it was reported from 41 States, a decrease of 1—Michigan. Pennsylvania in 1916, as for many years, was the leading front-brick producing State and reported about 27 per cent of the total quantity and value. Ohio ranked second, Indiana third, and Illinois fourth in both quantity and value. Kansas was fifth in quantity and seventh in value, as in 1915. Missouri was sixth in quantity and fifth in value. The average price per thousand ranged from $9.30 in Oklahoma to $25 in Arizona and increased 29 cents, to $11.43. There was an increase in the quantity of front brick reported in 1916 of 147,094,000 brick.

Draintile, the sixth brick and tile product in value in 1916, was reported from 36 States, the same number as for 1915 Louisiana and New Mexico, which reported none for 1915, entered the list of producers, and Montana and Vermont reported none. The Middle West continues to be the largest producer and user of draintile. Iowa, Ohio, Indiana, Illinois, Michigan, and Minnesota were the leading States in the order named. These six States, together reported draintile valued at $9,091,005, or 90 per cent of the total. This was an increase of $1,052,004, or 13 per cent, over 1915. All of these leading States showed large increase over 1915.

Sewer pipe, the third brick and tile product in value in 1916, was reported from 26 States, a decrease of 1—West Virginia. Ohio was the leading producer and reported 38 per cent of the value of the entire output. Missouri ranked second, Pennsylvania third, California fourth, and Illinois fifth. These five States reported 68 per cent of the total in 1916, and all showed large increase over 1915.

Architectural terra cotta was reported from 12 States in 1916, the same as in 1915. In only six States was there a sufficient number of producers to permit the publication of figures without disclosing confidential information. Illinois was the leading State in 1916, displacing New Jersey, which was second, and New York was third. These three States reported 70 per cent of the total for 1916.

Fireproofing, including hollow building tile or block, was reported from 35 States, the same number as in 1915. Ohio was the leading State, as in 1915, and reported 28 per cent of the total. New Jersey ranked second and Iowa third, as in 1915. These three States reported 58 per cent of the total in 1916, and each showed a very large increase.

Tile, not drain, includes roofing, floor, wall, mosaic ceramic, and faience tile. These products were reported from 17 States, the same

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number as in 1915, Tennessee entering the list of producers and Oregon dropping out. Ohio continues to be the leading State, reporting 40 per cent of the total. New Jersey was second and Indiana third. These three States reported 71 per cent of the total in 1916.

Fire brick ranks second in value among brick and tile products, and was reported from 32 States in 1916, a decrease of 3. Kansas and Mississippi entered the list of producers, and Iowa, Michigan, North Carolina, South Carolina, and Wyoming dropped out. The quantity of 9-inch equivalent fire brick reported, including silica brick, increased 412,940,000 brick, or 43 per cent, and the value increased $11,966,198, or 64 per cent. The average price per thousand in 1916 for all fire brick was $22.37, an increase of $2.83. The total number of clay 9-inch equivalent brick was 1,166,592,000, valued at $25,155,519, or $21.56 per thousand, an increase of 332,853,000 brick, or 40 per cent, and of $9,355,457, or 59 per cent, in value. Pennsylvania continues to be the leading producer of both clay and silica fire brick, reporting 44 per cent of the quantity and value of the clay fire brick and 79 per cent of the quantity and 74 per cent of the value of silica fire brick in 1916. If clay and silica fire brick be considered together, Pennsylvania marketed one-half of the quantity, and nearly one-half—49 per cent—of the total value reported for 1916. Ohio was second in quantity and value, Missouri was third, Kentucky fourth, and New Jersey fifth, as in 1915 and 1914. These five States reported 84 per cent of the quantity and 83 per cent of the value of clay fire brick in 1916.

The production of silica fire brick in 1916 was 210,331,000 9-inch equivalent brick, valued at $5,650,610, or $26.87 per thousand, an increase of 80,087,000 brick and of $2,610,741. The average price per thousand increased $3.53 in 1916 compared with 1915.

TILE, NOT DRAIN.

Under the head "Tile, not drain," are embraced the varieties of higher grades of tile used almost exclusively in structural work. There are numerous subdivisions and trade names for these varieties, but, owing to the small number of producers of some of them, it has been thought best to classify them as roofing, floor, ceramic mosaic, faïence, and wall tile.

Tile, not drain, of domestic production sold in the United States, 1913–1916.

Variety.	1913		1914		1915		1916	
	Value.	Number of firms reporting sales.	Value.	Number of firms reporting sales.	Value.	Number of firms reporting sales.	Value.	Number of firms reporting sales.
Roofing	$1,130,286	24	$1,043,020	26	$891,150	23	$914,240	21
Floor	2,483,082	39	881,362	41	912,180	44	1,438,231	49
Ceramic mosaic	(a)	.....	1,520,739	18	1,185,787	19	1,308,861	19
Faïence	731,820	23	675,615	23	635,073	23	814,077	24
Wall	1,763,992	15	1,584,847	19	1,561,865	19	2,000,055	16
	6,109,180	.....	5,705,583	.....	5,186,055	.....	6,475,464	.....

a Not separately classified.

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Wall tile is the variety of greatest value and increased largely over 1915. If, however, floor tile and ceramic mosaics, which are used almost exclusively as floor tile, be considered together, tile used for flooring was valued at $2,747,092, represented 42 per cent of the total, and showed an increase of $649,125, or 31 per cent, over 1915.

Floor tile showed an increase of $526,051, and ceramic mosaic tile an increase of $123,074 over 1915. Floor tile was reported by 13 States, California, Illinois, Indiana, Iowa, Kentucky, Massachusetts, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Tennessee, and West Virginia, and by 49 producers. Ohio was the leading State, with sales valued at $585,692, or more than 40 per cent of the total, and an increase of $292,136, or 100 per cent. New Jersey was second and Indiana third, as in 1915. These three States reported nearly three-fourths of the entire output of this variety of tile. Ceramic mosaics were reported from Colorado, Indiana, Kentucky, Massachusetts, New Jersey, New York, Ohio, and Pennsylvania. Ohio was the leading State, with wares valued at $467,623, a decrease of $93,663, from 1915; New Jersey was second, with a production valued at $430,798. These two States produced 69 per cent of the total for this variety.

Wall tile, constituting 31 per cent of all tile other than draintile in 1916 and showing an increase in value of $438,190, or 28 per cent, over 1915, was reported from Indiana, Kentucky, Missouri, New Jersey, Ohio, and Pennsylvania. Ohio was the leading State, and reported an output valued at $807,063, or 40 per cent of the total, an increase of $74,274, or 10 per cent, over 1915. New Jersey was second, with an output valued at $518,203, or 26 per cent of the total, an increase of $119,945, or 30 per cent, over 1915.

Roofing tile showed an increase of $23,090, or 3 per cent, over 1915, and was reported from 11 States in 1916, California, Colorado, Indiana, Iowa, Kansas, Kentucky, Michigan, Missouri, Ohio, Pennsylvania, and West Virginia. Ohio was the leading State, reporting an output valued at $399,094, a small decrease from 1915. California was second and Kansas third.

Faïence tile was reported from 10 States, California, Colorado, Indiana, Kentucky, Massachusetts, Michigan, New Jersey, Ohio, Pennsylvania, and West Virginia, in 1916, and showed an increase of $179,004, or 28 per cent, over 1915. Ohio was the leading State, and reported faïence tile marketed to the value of $356,382, or 44 per cent of the total, an increase of $25,738, or 8 per cent, over 1915. New Jersey was second, with $109,223, an increase of $30,025.

HUDSON RIVER REGION.

Greater New York is the leading common-brick market in the United States, about a billion brick being used there annually. The principal source of this supply is the Hudson River region, extending from New York to Cohoes, on both sides of the river. Bergen County, N. J., has contributed largely to this market, and within the last few years the Raritan River region, in Middlesex County, N. J., has also sent the larger portion of its output of common brick to the New York market. For this reason it is included in the table showing the output of the Hudson River region. Connecticut also is at times a contributor to the New York City brick market. The

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water transportation enjoyed by the Hudson River yards and those located in the Hackensack and Raritan districts gives them a great advantage, and it is only when the prices are high—about $7 a thousand—that Connecticut brick can profitably enter the New York City market. Notwithstanding the high prices of brick in New York City in 1916, it is believed that few, if any, Connecticut brick entered that market, as the local demand for brick was sufficient to prevent the shipping of brick into New York.

The year 1916 was notable in this region principally for the increase in value of the output and the decrease in quantity of brick marketed during a period of very great building activity. The general conditions were good, the demand for brick in New York City was steady, and prices were high. The weather conditions were favorable, and the output would have been larger but for lack of labor.

Common brick produced and sold in the Hudson River district, 1901–1916.

Year.	Number of firms reporting sales.	Quantity (thousands).	Value.	Average price per thousand.
1901	127	830,154	$3,880,215	$4.67
1902	127	833,065	3,683,379	4.42
1903	115	844,500	3,973,316	4.70
1904	119	987,644	5,810,114	5.88
1905	129	1,297,389	9,063,753	6.99
1906	135	1,274,372	7,672,639	6.02
1907	132	1,064,892	5,515,585	5.18
1908	123	875,979	4,107,382	4.69
1909	127	1,313,760	6,438,642	4.90
1910	135	1,142,284	5,544,600	4.85
1911	125	926,072	4,717,633	5.09
1912[a]	136	1,233,187	7,133,177	5.78
1913[a]	132	1,025,308	5,636,061	5.50
1914[a]	129	888,266	4,350,832	4.90
1915[a]	120	960,527	5,009,065	5.21
1916[a]	113	893,552	5,915,254	6.62

[a] Includes Raritan district, New Jersey.

The number of brick marketed in this region in 1916 decreased 66,975,000, or 7 per cent, and the value increased $906,189, or 18 per cent. The average price per 1,000 brick for the region increased $1.41 compared with 1915, and was the highest recorded except in 1905. The number of operators reporting sales continues to decrease and in 1916 was the smallest recorded.

In the New York and Bergen County, N. J., portion of the region the output was 744,978,000 brick, a decrease of 31,889,000 brick, valued at $4,853,946, an increase of $911,552 over 1915. The number of operators (105) reporting sales in 1916 decreased 6 as compared with 1915.

In 1916, for the first time, Cook County, Ill., exceeded the New York portion of the Hudson River region in output and value of common brick.

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Common brick marketed in the Hudson River district (from Cohoes to New York City) and in Raritan district, N. J., in 1915 and 1916.

County.	1915				1916			
	Common brick.				Common brick.			
	Number of firms reporting sales.	Quantity (thousands).	Value.	Average price per thousand.	Number of firms reporting sales.	Quantity (thousands).	Value.	Average price per thousand.
Albany	12	65,712	$385,945	$5.87	13	71,183	$442,640	$6.22
Columbia	5	56,003	266,515	4.76	[a]8	[a]70,526	[a]417,713	5.92
Dutchess	15	117,711	592,278	5.03	14	87,779	552,271	6.29
Green	6	28,289	137,083	4.85	6	29,683	182,524	6.15
Orange	8	91,889	447,273	4.87	7	80,450	577,829	7.18
Rensselaer	4	9,111	52,646	5.78	(a)	(a)	(a)	(a)
Rockland	23	95,880	507,414	5.29	20	121,967	809,019	6.63
Ulster	22	229,343	1,110,492	4.84	22	222,651	1,444,275	6.49
Westchester	6	47,630	244,902	5.14	6	18,357	126,197	6.87
Total for New York portion of district	101	741,568	3,744,548	5.05	96	702,596	4,552,468	6.48
Bergen County, N. J.	10	35,299	197,846	5.60	9	42,382	301,478	7.11
Raritan district (Middlesex County), N. J.	9	183,660	1,066,671	5.81	8	148,574	1,061,308	7.14
Grand total	120	960,527	5,009,065	5.21	113	893,552	5,915,254	6.62

[a] Columbia and Rensselaer counties are combined.

New York's portion of the region has by reason of its greater number of operators always been by far the larger producer. For 1916 it reported 79 per cent of the output and 77 per cent of the value of the entire region. The quantity of brick sold in this portion of the region in 1916 decreased 38,972,000 brick, or 5 per cent, the value, however, increased $807,920, or 22 per cent, compared with 1915.

Of the counties included in the New York portion, Ulster, as for many years, was first in output and value, its 22 operators reporting 32 per cent of the quantity and value in 1916, a decrease of 6,692,000 brick, or 3 per cent, but an increase in value of $333,783, or 30 per cent, compared with 1915. The average price per 1,000 in this county increased $1.65. Rockland County was second, displacing Dutchess County, which was third in quantity and fourth in value. The marketed production of Rockland County increased 26,087,000 brick, or 27 per cent, and the value increased $301,605, or 59 per cent. The average price per 1,000 brick in this county increased $1.34. In Dutchess County there was a decrease of 29,932,000 brick, or 25 per cent, and of $40,007, or 7 per cent, from 1915. Of the 9 counties in New York, five showed increase in quantity and value; two, Orange and Ulster, showed decrease in quantity and increase in value; and two, Dutchess and Westchester, showed decrease in quantity and value. The greatest increase in quantity was in Rockland County and the greatest increase in value was in Ulster County. The average price per 1,000 increased in every county, Orange showing the largest increase—$2.31.

New Jersey's portion of the production of this region was comparatively small—190,956,000 brick, valued at $1,362,786—but owing to the higher prices obtained in 1916, its proportionate value was some-

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what larger, the proportion being 21 per cent of the quantity and 23 per cent of the value. Middlesex County's output and value showed decrease in 1916, but Bergen County's output and value increased—7,083,000 brick, or 20 per cent, and $103,632, or 52 per cent, the net increase in value being $98,269, or 8 per cent. There was a net decrease in quantity in this portion of the region of 28,003,000 brick. The average price per 1,000 brick in the New Jersey portion of the region was $7.14 in 1916 and $5.78 in 1915.

The number of operators reporting sales decreased seven, of whom five were in the New York portion of the region.

POTTERY.

INTRODUCTION.

The increasing prosperity in the pottery industry in 1915 continued during 1916, the year opening with a greater volume of business than was ever known at that season. The great decrease of imports, their virtual cessation from Germany—from which in normal times much of the imported pottery was derived—and the prosperous conditions at home, created an unprecedented demand for domestic wares. Potteries were crowded with orders and the value of the pottery products was by far the greatest in the history of the domestic industry, exceeding that of 1913, the last year of normal conditions. But for labor strikes and scarcity of workers in East Liverpool, Ohio, and vicinity and the lack of raw materials on account of congested transportation, even this great record would have been exceeded.

This increase was due primarily to a larger volume of business, but some of it was due to higher prices for the wares. It should be said, however, to the credit of the operating potteries, that they refused to increase the price of their wares until it was made necessary by the greatly increased cost of labor and raw materials, the advances in prices of domestic pottery coming a year after foreign wares had been advanced.

PRODUCTION.

The value of all domestic pottery marketed in 1916 was $48,217,242, an increase of $10,891,854, or nearly 30 per cent, over 1915 and of $10,224,867, or 27 per cent, over 1913, the previous year of highest value. The pottery imports decreased $1,027,501, or 16 per cent, and the ratio of production to consumption, 92 per cent, was the highest recorded.

Every variety of ware as classified in this report showed increase in 1916 as compared with 1915, where comparison can be made, and reached its maximum value in 1916. No comparison can be made with regard to the production of chemical pottery, as it has not been reported separately before 1916. Sanitary ware showed the largest increase, $3,118,201, or 39 per cent; white ware increased $2,867,148; and china, the highest grade of pottery, increased $1,148,216, or nearly 50 per cent.

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The value of white ware and china, which comprise the general household wares and constitute nearly 50 per cent of all pottery products, was $21,669,762 in 1916, an increase of $4,015,364 over 1915. If to this sum is added the value of sanitary ware and porcelain electrical supplies the total value in 1916 was $39,815,599, or $9,496,783 more than in 1915.

Value of pottery products in the United States, 1907–1916.

Year.	Number of firms reporting sales.	Red earthenware.	Stoneware and yellow and Rockingham ware.	Chemical stoneware and porcelain.	White ware, including C. C. ware, etc.
1907	509	$845,465	$4,280,601	(a)	$13,913,680
1908	497	757,900	3,518,841	(a)	11,474,147
1909	466	805,906	3,993,859	(a)	13,728,316
1910	463	854,196	3,796,688	(a)	14,780,980
1911	449	893,678	4,120,608	(a)	14,366,251
1912	434	958,270	3,919,778	(a)	14,829,431
1913	426	1,000,529	3,683,567	(a)	15,066,811
1914	412	1,059,904	3,349,301	(a)	14,968,079
1915	416	1,072,061	3,575,603	(a)	15,324,242
1916	393	1,156,351	3,696,288	$1,054,061	18,191,390

Year.	China, bone china, delft, and belleek ware.	Sanitary ware.	Porcelain electrical supplies.	Miscellaneous.	Total.
1907	$1,930,669	$4,863,222	$2,613,771	$1,696,066	$30,143,474
1908	1,581,020	4,373,590	2,009,005	1,421,052	25,135,555
1909	b 1,766,766	5,989,295	3,047,499	b 1,717,800	31,049,441
1910	1,962,126	6,758,996	3,794,153	1,837,539	33,784,678
1911	2,057,985	7,031,458	4,232,101	1,816,479	34,518,560
1912	2,177,305	7,902,255	4,927,316	1,789,809	36,504,164
1913	2,424,060	8,214,838	5,737,741	1,864,829	37,992,375
1914	2,384,686	7,874,269	4,130,270	1,631,652	35,398,161
1915	2,330,156	7,993,216	4,671,202	2,358,908	37,325,388
1916	3,478,372	11,111,417	7,034,420	2,494,943	48,217,242

a Chemical stoneware and chemical porcelain were not separately classified prior to 1916.
b China, bone china, delft, and belleek ware for Ohio is included in miscellaneous.

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Value of pottery products in 1915.

Rank of State.	State.	Number of firms reporting sales.	Red earthenware.	Stoneware and yellow and Rockingham ware.	White ware, including C. C. ware, white granite, semiporcelain ware, and semivitreous porcelain ware.	China, bone china, delft, and belleek ware.
19	Alabama	13	$6,741	$8,556		
16	Arkansas	3	(a)	(a)		
9	California	12	32,663	(a)		
15	Colorado	5	(a)	(a)		
	Connecticut		(a)	(a)		
	District of Columbia		(a)			
17	Georgia	17	11,452	6,725		
7	Illinois	21	40,810	572,958	(a)	
6	Indiana	11	3,818	44,551	(a)	
23	Iowa	3	(a)	(a)		
	Kansas			(a)		
12	Kentucky	7	43,839	65,000		
	Louisiana		(a)			
	Maine			(a)		
10	Maryland	6	(a)		(a)	
11	Massachusetts	8	(a)	(a)	(a)	
8	Michigan	6	112,863		(a)	
	Minnesota		(a)	(a)		
18	Mississippi	8	835	14,855		
24	Missouri	3	(a)	(a)		
	Montana		(a)			
	Nebraska		(a)			
	New Hampshire					
2	New Jersey	54	34,600	91,815	$665,633	$983,855
4	New York	21	39,921	(a)	(a)	833,301
20	North Carolina	23	2,504	8,190		
1	Ohio	104	336,038	1,864,450	10,184,834	
	Oregon		(a)	(a)		
5	Pennsylvania	22	176,791	228,205	(a)	(a)
	Porto Rico		(a)			
21	South Carolina	5	7,581	(a)		
13	Tennessee	9	3,975	21,704		
14	Texas	16	14,723	50,666		
	Utah		(a)			
	Virginia					
	Washington		(a)			
3	West Virginia	14			2,837,766	(a)
22	Wisconsin	3	8,359			
	Undistributed[b]	22	194,548	597,928	1,636,009	513,000
		416	1,072,061	3,575,603	15,324,242	2,330,156
	Percentage of pottery products		2.87	9.58	41.06	6.24
	Percentage of total clay products		.66	2.19	9.39	1.43
	Number of firms reporting each variety		156	136	57	14

[a] Included in "Undistributed." [b] Includes all products made by less than 3 producers in 1 State.

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Value of pottery products in 1915—Continued.

Rank of State.	State.	Sanitary ware.	Porcelain electrical supplies.	Miscellaneous.[a]	Total.	Percentage of total.
19	Alabama				$15,297	0.04
16	Arkansas			(b)	20,285	.05
9	California	$266,353		$34,862	368,094	.99
15	Colorado			25,585	62,885	.17
	Connecticut		(b)		(b)	
	District of Columbia				(b)	
17	Georgia				18,177	.05
7	Illinois	(b)	(b)	14,812	948,892	2.54
6	Indiana	757,115	(b)		1,198,034	3.21
23	Iowa			(b)	5,425	.01
	Kansas				(b)	
12	Kentucky				108,839	.29
	Louisiana			(b)	(b)	
	Maine				(b)	
10	Maryland	(b)	(b)	(b)	206,718	.55
11	Massachusetts			11,561	184,233	.49
8	Michigan		(b)	(b)	521,989	1.40
	Minnesota				(b)	
18	Mississippi				15,690	.04
24	Missouri				3,166	.01
	Montana				(b)	
	Nebraska				(b)	
	New Hampshire			(b)	(b)	
2	New Jersey	4,793,406	$1,028,992	451,037	8,049,338	21.57
4	New York	(b)	1,153,068	115,394	2,441,740	6.54
20	North Carolina			(b)	11,394	.03
1	Ohio	591,455	1,489,614	1,463,388	15,929,779	42.68
	Oregon				(b)	
5	Pennsylvania	(b)	(b)	23,220	1,827,749	4.90
	Porto Rico				(b)	
21	South Carolina				8,981	.02
13	Tennessee			(b)	106,389	.29
14	Texas				65,389	.18
	Utah				(b)	
	Virginia			(b)	(b)	
	Washington				(b)	
3	West Virginia	1,056,585	(b)	66,944	4,510,623	12.00
22	Wisconsin				8,359	.02
	Undistributed[c]	528,302	999,528	152,105	[d] 687,923	1.84
		7,993,216	4,671,202	2,358,908	37,325,388	100.00
	Percentage of pottery products	21.42	12.51	6.32	100.00	
	Percentage of total clay products	4.90	2.86	1.45	22.88	
	Number of firms reporting each variety	43	40	70		

[a] Including aquarium ornaments, art pottery, casseroles, chemical stoneware, cuspidors, filter disks, jardinieres, Cracquile porcelain, Guernsey earthenware, Hampshire, Niloak, Omar Khayyam, Pewabic, Rookwood, and Teco pottery, magnesia ware, mantle rings, Oxfordware, pins, stilts, and spurs for potters' use, porcelain door knobs, shuttle eyes, and thread guides, porcelain hardware trimmings, refrigerator linings, tobacco pipes, toy marbles, turpentine cups, umbrella stands, and vases.

[b] Included in "Undistributed."

[c] Includes all products made by less than 3 producers in 1 State.

[d] Made up of State totals of Connecticut, District of Columbia, Kansas, Louisiana, Maine, Minnesota, Montana, Nebraska, New Hampshire, Oregon, Porto Rico, Utah, Virginia, and Washington.

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Value of pottery products in 1916.

Rank of State.	State.	Number of firms reporting sales.	Red earthenware.	Stoneware and yellow and Rockingham ware.	Chemical stoneware and porcelain.	White ware, including C. C. ware, white granite, semiporcelain ware, and semivitreous porcelain ware.	China, bone china, delft, and Belleek ware.
16	Alabama	9	$4,121	$9,254			
	Arkansas		(a)	(a)			
9	California	13	32,350	(a)	(a)		
14	Colorado	5	(a)	(a)	(a)		
	Connecticut		(a)				
	District of Columbia		(a)				
17	Georgia	16	7,493	5,708			
7	Illinois	18	46,843	548,533		(a)	
6	Indiana	11	(a)	41,001		(a)	
	Iowa		(a)				
13	Kentucky	7	49,703	71,408			
	Louisiana		(a)				
	Maine			(a)			
11	Maryland	6	(a)			(a)	
12	Massachusetts	9	(a)	(a)	(a)	(a)	
8	Michigan	7	123,734		(a)	(a)	
	Minnesota		(a)	(a)			
18	Mississippi	6	860	11,060			
21	Missouri	3	(a)	(a)			
	Montana		(a)				
	Nebraska		(a)				
	New Hampshire						
2	New Jersey	51	37,529	(a)	(a)	$811,391	$1,407,930
4	New York	18	(a)	(a)	(a)	(a)	1,254,374
19	North Carolina	18	1,290	7,805			
1	Ohio	98	323,777	1,938,726	$486,171	11,834,913	
	Oregon		(a)	(a)			
5	Pennsylvania	25	215,115	218,624	(a)	(a)	(a)
	Porto Rico		(a)				
20	South Carolina	6	7,030	1,690			
10	Tennessee	8	(a)	24,850			
15	Texas	18	13,831	74,099			
	Utah		(a)	(a)			
	Virginia						
	Washington		(a)				
3	West Virginia	15				3,576,510	(a)
	Wisconsin		(a)				
	Undistributed [b]	26	292,675	743,430	567,890	1,968,576	816,068
		393	1,156,351	3,696,288	1,054,061	18,191,390	3,478,372
	Percentage of pottery products		2.40	7.67	2.19	37.73	7.21
	Percentage of total clay products		.56	1.78	.51	8.78	1.68
	Number of firms reporting each variety		136	126	16	54	17

[a] Included in "Undistributed." [b] Includes all products made by less than 3 producers in 1 State.

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Value of pottery products in 1916—Continued.

Rank of State.	State.	Sanitary ware.	Porcelain electrical supplies.	Miscellaneous.[a]	Total.	Percentage of total.
16	Alabama			(b)	$22,805	0.05
	Arkansas			(b)	(b)	
9	California	$393,867		$19,093	517,797	1.07
14	Colorado			20,067	111,569	.23
	Connecticut		(b)		(b)	
	District of Columbia				(b)	
17	Georgia				13,201	.03
7	Illinois	(b)	(b)	42,565	1,125,506	2.33
6	Indiana	1,140,455	(b)		1,634,353	3.39
	Iowa			(b)	(b)	
13	Kentucky				121,111	.25
	Louisiana			(b)	(b)	
	Maine				(b)	
11	Maryland	(b)	(b)	(b)	277,575	.58
12	Massachusetts			31,714	230,321	.48
8	Michigan	(b)	(b)	(b)	792,716	1.64
	Minnesota				(b)	
18	Mississippi				11,920	.03
21	Missouri				6,436	.01
	Montana				(b)	
	Nebraska				(b)	
	New Hampshire			(b)	(b)	
2	New Jersey	6,458,356	$1,674,093	177,218	11,064,878	22.95
4	New York	(b)	1,623,433	40,763	3,344,672	6.94
19	North Carolina			(b)	9,860	.02
1	Ohio	941,643	2,181,026	1,735,277	19,441,533	40.32
	Oregon				(b)	
5	Pennsylvania	(b)	(b)	(b)	2,490,127	5.14
	Porto Rico				(b)	
20	South Carolina				8,720	.02
10	Tennessee			(b)	304,638	.63
15	Texas			(b)	88,180	.18
	Utah				(b)	
	Virginia	(b)		(b)	(b)	
	Washington				(b)	
3	West Virginia	1,310,949	(b)	86,469	5,780,853	11.99
	Wisconsin				(b)	
	Undistributed[c]	866,147	1,555,868	341,777	[d] 827,971	1.72
		11,111,417	7,034,420	2,494,943	48,217,242	100.00
	Percentage of pottery products	23.04	14.59	5.17	100.00	
	Percentage of total clay products	5.36	3.40	1.20	23.27	
	Number of firms reporting each variety	46	42	66		

[a] Including aquarium ornaments, art pottery, Craequle porcelain, filter stones, gas and electric lighting appliances, jardinieres, porcelain door knobs, shuttle eyes and thread guides, porcelain hardware trimmings, Guernsey earthenware, Niloak, Omar Khayyam, Pewabic, Rookwood, and Teco pottery, Oxfordware, pins, stilts, and spurs for potters' use, refrigerator linings, saggers, tobacco pipes, toy marbles, turpentine cups, umbrella stands, and vases.

[b] Included in "Undistributed."

[c] Includes all products made by less than 3 producers in 1 State.

[d] Made up of State totals of Arkansas, Connecticut, District of Columbia, Iowa, Louisiana, Maine, Minnesota, Montana, Nebraska, New Hampshire, Oregon, Porto Rico, Utah, Virginia, Washington, and Wisconsin.

The number of States reporting ware classed in this report as pottery was 37 in 1916, a decrease of 1, Kansas. The important producing States, especially those reporting the higher grades of ware, are few. Only 3 States, New Jersey, New York, and Pennsylvania, produced all kinds of ware, and Ohio all but one.

Ohio, the leading pottery-producing State of the Union, reported in 1916 wares valued at $19,441,533, or 46 per cent of the total, an increase of $3,511,754, or 22 per cent, over 1915. Ohio's principal pottery product is white ware, which constituted 60 per cent of the value of the entire pottery output of the State in 1916. Ohio's second product in importance in 1916 was porcelain electrical supplies, which increased in value $691,412, or 46 per cent, over 1915.

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New Jersey is the second largest pottery-producing State. For 1916 it reported wares valued at $11,064,878, or nearly 23 per cent of the total, an increase of $3,015,540, or 37 per cent, over 1915. The principal pottery product of New Jersey is sanitary ware, which constituted 58 per cent of the State total in 1916. West Virginia ranks third among the pottery-producing States and reported nearly 12 per cent of the total for 1916. Its pottery products increased $1,270,230, or 28 per cent, in value in 1916 over 1915. West Virginia's principal pottery product is white ware, which constituted 61 per cent of its total in 1916. It is also a large producer of sanitary ware. New York was fourth and Pennsylvania was fifth, as for many years. Indiana, Illinois, and Michigan maintained their relative ranks of sixth, seventh, and eighth, respectively. The value of pottery output in all these States increased very considerably in 1916 compared with 1915. The first five States, Ohio, New Jersey, West Virginia, New York, and Pennsylvania, reported wares valued at $42,112,063, or 87 per cent of the total in 1916.

In considering the rank of States it should be borne in mind that the small number of producers in many of them in 1916, which made it impossible to publish State totals without disclosing individual returns, makes the rank of all but the first few the relative and not the actual rank.

Red earthenware, which consists principally of flower pots, the commonest of pottery products, was reported from 33 States. Ohio was the leading State in 1916, as for many years, and showed a small decrease from 1915. Pennsylvania and Massachusetts ranked second and third, respectively. These three States reported 60 per cent of the total for 1916. The number of producers reporting this ware decreased by 20 in 1916, compared with 1915.

Stoneware, including yellow and Rockingham ware, was reported from 23 States in 1916, a decrease of 2 States, Connecticut, Iowa, and Kansas dropping out and Utah reporting a small output. Ohio, the leading State, reported more than half the entire output.

For the first time efforts were made to obtain statistics of production of chemical stoneware and chemical porcelain as distinguished from the lower grades of stoneware. Much of the chemical pottery, especially the chemical porcelain used in this country before the European war, was imported from Germany. Chemical pottery was reported by 16 producers in 8 States, and the output was valued as $1,054,061. Ohio was the leading State, reporting ware valued at $486,171, and New Jersey was second. These two States reported 80 per cent of the value of the output of the entire country.

The pottery products of the United States having the largest total value are grouped under the head of white ware. These include the various household wares and constituted in 1916 nearly 38 per cent of the total value of all pottery products. White-ware products were reported by 54 operators in 10 States in 1916, a decrease of 3 operators from 1915. As there were less than three producers in each of 7 States, totals for only 3 States are published in order to avoid disclosing confidential information. Ohio was the leading State in the production of these wares in 1916, as for many years, and reported 65 per cent of the total value, an increase of $1,650,079, or 16 per cent, over 1915. Of the 54 operators reporting white ware in 1916, 36 were located in

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Ohio. West Virginia ranked second and showed an increase in value of $738,744, or 26 per cent.

China was reported from 4 States in 1916 as in 1915—New Jersey, New York, Pennsylvania, and West Virginia. New Jersey reported 40 per cent of the total value of china in 1916, its production increasing $424,075, or 43 per cent, compared with 1915. New York ranked second and showed an increase of $421,073, or 51 per cent, over 1915. Three more operators reported china in 1916 than in 1915.

Sanitary ware was reported from 11 States in 1916, an increase of 2 States—Michigan and Virginia. New Jersey was the leading State and reported nearly 60 per cent of the entire output. West Virginia was second and Indiana third. These relative ranks have been maintained for many years. These three States showed large increases in value of output in 1916. The number of operators reporting sanitary ware in 1916 was 46, an increase of 3 over 1915.

Porcelain electrical supplies were reported by 10 States, as in 1915. Ohio, New Jersey, and New York are the leading States in the order named, and they reported 78 per cent of the value of the output. All these States showed large increases in 1916 over 1915. The number of operators reporting porcelain electrical supplies in 1916 was 42, an increase of 2 over 1915.

CONSUMPTION.

The value of the pottery imported into the United States in 1916, added to that of the pottery produced and sold, amounted to a total of $53,817,827. After deducting from this sum the value of the exports of domestic ware, approximately $1,076,572, and of the re-exports of foreign ware, $81,223, the value of the apparent net consumption was $52,660,032, of which the domestic production was 92 per cent, by far the highest proportion yet reached. In 1915 this percentage was 86; in 1914 it was 82; in 1913 it was 80; and in 1912 it was 81.

IMPORTS.[1]

The total value of imports of all clay products decreased $1,034,222, or 15 per cent, in 1916; in 1915 there was a decrease of $1,806,350, or nearly 21 per cent. The total value of imports for 1916 was the lowest in 30 years, except in 1890, and was less than that of 1907, the year of maximum value, by $8,045,267, or 58 per cent. Of the imports for 1916, about 97 per cent was pottery and about 3 per cent was brick and tile. The value of imports of pottery in 1916 decreased $1,027,501, or 16 per cent, from 1915, and was considerably less than half of the value of the pottery imported in 1907. In 1916 the imports of the higher grades of pottery constituted 95 per cent of the total. Brick and tile imports decreased $6,721, or 4 per cent, in 1916.

[1] Statistics of imports and exports are obtained from the reports and records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

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Value of clay products imported and entered for consumption in the United States, 1907–1916.

Year.	Pottery.								Brick, fire brick, tile, etc.	Grand total.
	Brown earthen and common stone ware.[a]	Tobacco pipes and pipe bowls of clay.	Earthenware and crockery composed of a nonvitrified absorbent body.		China and porcelain.		Sanitary earthenware, decorated and not decorated.	Total.		
			Not decorated.	Decorated.	Not decorated.	Decorated.				
1907	$113,477	.....	.....	.....	$1,315,591	$12,156,544	.....	$13,585,612	$225,320	$13,810,932
1908	70,629	.....	.....	.....	1,142,444	9,309,718	.....	10,522,791	162,341	10,685,132
1909	98,716	.....	.....	.....	1,245,479	9,263,017	.....	10,607,212	189,536	10,796,748
1910	154,614	$52,077	.....	.....	1,293,986	9,682,558	.....	11,183,235	222,183	11,405,418
1911	164,871	61,244	.....	.....	1,221,756	9,251,989	.....	10,699,860	208,966	10,908,826
1912	152,166	66,292	.....	.....	1,094,152	8,309,212	.....	9,621,822	215,379	9,837,201
1913	236,611	31,806	[b]$81,978	[b]$523,803	[c]1,067,209	8,273,681	.....	10,217,088	276,677	10,493,765
1914	312,934	40,548	438,460	1,968,561	727,725	4,910,365	.....	8,398,593	207,644	8,606,237
1915	227,017	15,155	272,795	1,538,732	458,302	4,116,085	.....	6,628,086	171,801	6,799,887
1916	264,715	10,378	173,192	1,669,712	289,219	3,177,998	$15,371	5,600,585	165,080	5,765,665

[a] Including Rockingham ware and miscellaneous pottery products.
[b] Figures cover period from Oct. 4 to Dec. 31.
[c] Including wares classified under the act of 1913 as china and porcelain wares composed of a vitrified nonabsorbent body: Not decorated, $244,933; decorated, $2,204,851. After 1913 only wares composed of a vitrified nonabsorbent body are included.

EXPORTS.

The value of exports of domestic clay products in 1916 increased $2,150,290, or 79 per cent, over 1915. In 1915 there was a decrease of $872,765, or 24 per cent, from 1914. Of the exports in 1916, 62 per cent was brick and tile, 22 per cent pottery, and 16 per cent unclassified.

Each of these classes of ware increased in 1916 compared with 1915. Brick and tile showed the largest increase, $1,467,826, or 95 per cent; pottery exports increased $513,120, or 90 per cent; and all other clay products increased $169,344, or 27 per cent. Exports of fire brick and china reached their maximum value in 1916.

Value of clay products of domestic manufacture exported from the United States, 1907–1916.

Year.	Building brick.	Fire brick.	Tile (except drain).	Earthen and stone ware.	China.	Sanitary earthenware.	All other.	Total.
1907	$185,192	$631,779	.....	$1,022,730	$108,911	.....	.....	$1,948,612
1908	.....	[a]550,243	.....	906,266	77,494	.....	$113,243	1,647,246
1909	.....	[a]1,002,270	.....	776,842	86,853	.....	147,622	2,013,587
1910	.....	[b]634,775	.....	928,475	113,214	.....	968,138	2,644,603
1911	.....	1,057,725	.....	1,278,892	122,474	.....	1,206,629	3,665,720
1912	[b]448,939	1,117,161	[b]$539,116	1,037,637	140,147	.....	1,717,895	5,000,895
1913	689,515	1,121,590	851,463	410,050	149,281	.....	1,566,340	4,788,239
1914	524,239	734,134	658,695	390,693	136,209	.....	1,134,035	3,578,005
1915	279,336	975,089	276,785	297,127	160,710	[b]$105,615	610,578	2,705,240
1916	189,668	2,406,184	403,184	600,377	262,119	214,076	779,922	4,855,530

[a] Includes all brick, other than building brick. [b] Figures cover period from July 1 to Dec. 31.

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Value of clay products of domestic manufacture exported from the United States in 1915 and 1916.

	Building brick.	Fire brick.	Tile (except drain).	Earthen and stone ware.	Sanitary earthenware.	China.	All other.	Total.
1915.								
Europe	$5,634	$81,583	$5,547	$16,935	$2,277	$16,691	$38,949	$167,616
Central America and West Indies	35,891	119,588	85,553	39,553	27,867	44,930	200,746	554,128
Canada	207,217	644,437	112,396	207,189	26,736	41,372	285,091	1,524,438
Mexico	10,614	38,248	2,397	4,330	2,803	6,576	23,434	88,402
Newfoundland	2,182	1,608	1,643	1,862	336	500	6,700	14,831
South America	13,711	66,155	35,420	18,375	36,465	17,231	30,203	217,560
Asia	3,750	13,048	6,575	4,050	3,058	6,335	11,305	48,121
Oceania	102	9,308	27,254	4,482	6,073	26,668	14,026	87,913
Africa	235	1,114	.....	351	.....	407	124	2,231
	279,336	975,089	276,785	297,127	[a] 105,615	160,710	610,578	2,705,240
1916.								
Europe	12,114	494,144	13,574	7,247	5,104	24,853	78,563	635,599
Central America and West Indies	35,483	272,165	155,878	95,674	105,630	78,546	247,786	991,162
Canada	122,519	1,349,994	149,907	425,758	42,593	91,408	317,774	2,499,953
Mexico	16,467	65,455	11,889	18,618	7,676	17,492	25,134	162,731
Newfoundland	15	18,647	1,663	1,197	2,624	1,200	1,297	26,643
South America	3,014	171,857	58,975	29,518	37,687	40,377	82,627	424,555
Asia	.....	18,291	2,873	14,544	6,704	3,856	9,449	55,717
Oceania	56	15,048	8,408	7,018	5,884	3,318	12,151	51,883
Africa	.....	583	17	803	174	569	5,141	7,287
	189,668	2,406,184	403,184	600,377	214,076	262,119	779,922	4,855,530

[a] Figures cover period from July 1 to Dec. 31.

Canada continues to afford the greatest foreign market for clay products exported from the United States, more than 50 per cent of such wares going to that country in 1916—an increase of $975,515, or 64 per cent, over 1915. Central America and the West Indies are the next largest consumers of American pottery, these countries taking 20 per cent of the total in 1916. Europe was third, displacing South America, and taking wares, mostly fire brick, valued at $635,599, or 13 per cent of the total, an increase of $467,983, or 279 per cent, over 1915.

CLAY PRODUCTS BY STATES.

In the following pages the statistics of the clay-working industries are given for some of the principal producing States. For tabular statements for these States for 1914 and other years the reader is referred to previous volumes of Mineral Resources.

ALABAMA.

The State of Alabama is rich in clays of many kinds, yet its rank as a clay-working State is low, being twenty-fifth in 1916. Its clay products in that year reported by 57 operators were valued at $1,520,301—brick and tile, $1,497,496; pottery, $22,805—an increase of $327,279, or more than 27 per cent. Alabama ranked third in value of silica brick and fourth in its output, and eighth in quantity and tenth in value of vitrified brick or block. Its principal clay product was common brick, valued at $497,446, or 33 per cent of the State total, an increase of $115,354. The quantity of common brick

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marketed in 1916 was 85,655,000 brick, an increase of 14,974,000 brick. Vitrified brick or block was Alabama's clay product of second value, but as less than three producers reported it for 1916, figures can not be given. Pottery products of Alabama are of minor importance, constituting less than 2 per cent of the value of the clay products of the State. Fire brick, including silica fire brick, was the leading product in Alabama and constituted over a third of the value of the clay products of the State.

Jefferson County was the principal clay-working county, and reported a production valued at $1,060,682, or 70 per cent of the State's total, and an increase of $245,344 compared with 1915. Nearly all of the fire brick and vitrified brick or block produced in the State came from Jefferson County. The principal common brick-producing counties, named in the order of the value of their output were Jefferson, Montgomery, and Talladega.

CALIFORNIA.

California, the most important of the Far Western States in the clay-working industries, Iowa and Missouri being the only States west of the Mississippi to exceed it, ranked tenth in value of clay products in 1916, 79 operators reporting for that year. It was fourth in value of sewer pipe and enameled brick, fifth in sanitary ware, sixth in value of architectural terra cotta, eighth in quantity and value of fire brick, tenth in value of fireproofing, and twelfth in value of common brick. California reported every variety of ware as classified in this report except fancy brick, silica fire brick, white ware, china, and porcelain electrical supplies.

The total value of California's clay products in 1916 was $4,163,426—brick and tile, $3,645,629; pottery, $517,797—an increase of $564,051, or nearly 16 per cent. California's principal clay product, common brick, made chiefly in Los Angeles and Contra Costa counties, was valued in 1916 at $1,107, 940, or 27 per cent of the value of all clay products in the State, an increase of $126,052. Sewer pipe, made chiefly in Los Angeles and Alameda counties, was second in value, $772,295, an increase of $64,815. California's principal pottery product is sanitary ware, made chiefly in Contra Costa County, valued at $393,867 in 1916, an increase of $127,514.

Los Angeles, the principal common-brick producing county, reported 70,415,000 brick, valued at $417,114, or 42 per cent of the quantity and 38 per cent of the value of common brick for the State, a decrease of 6,581,000 brick and of $18,857 in value. The principal clay product of Los Angeles County was common brick; sewer pipe ($255,632) was second, and fire brick ($190,303) third. Front brick, enameled brick, draintile, fireproofing, tile, not drain, and stove lining were also reported from this county in 1916. Contra Costa was the leading pottery-producing county, reporting nearly 70 per cent of the value of the pottery for the State. Sanitary ware is its only pottery product. Los Angeles was also the leading clay-working county and reported wares valued at $1,322,202, a small increase over 1915.

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COLORADO.

Colorado ranked eighteenth in value of clay products in 1916, rising from twenty-third in 1915; its 49 operators reported clay products valued at $1,930,039—brick, and tile, $1,818,470; pottery, $111,569—an increase of $664,934, or nearly 53 per cent over 1915. Colorado's principal clay product was fire brick, valued at $412,511, an increase of $156,452, or 61 per cent. Colorado ranked fourth in value of fancy or ornamental brick, fifth in quantity and value of silica fire brick, ninth in quantity and eleventh in value of clay fire brick, and tenth in value of draintile.

Denver County was the chief producer of common brick, reporting 24,537,000 brick, valued at $158,328, an increase of 6,323,000 brick and of $40,832. Jefferson County was the principal pottery-producing county. Fire brick was produced most largely in Pueblo County, with Denver County second. Denver is the principal clay-working county, reporting wares valued at $994,191, or 52 per cent of the State's total. This was an increase in 1916 of $273,410.

CONNECTICUT AND RHODE ISLAND.

There being fewer than three producers in Rhode Island, it is impossible to publish figures for the State without disclosing confidential returns, and they are combined with those of Connecticut. The value of the brick and tile products of these two States in 1916 was $1,762,653, an increase of $243,880 over 1915. Connecticut's products were common brick, fireproofing, stove lining, fire brick, red earthenware, and porcelain electrical supplies. Rhode Island reported common, vitrified, front, and fancy brick, and tile, not drain. Common brick, valued at $1,640,349 constituted 93 per cent of the total value of the brick and tile products of the two States, an increase of $258,262. Hartford is the leading county in Connecticut; it reported brick and tile products valued at $878,775, or more than half of the value for the entire State, and reported also more than half of the quantity and value of common brick marketed in these States. New Haven and Middlesex counties are also large producers of common brick. Fire brick is made only in New Haven County and pottery only in Hartford County.

These States were twenty-first in the value of clay in 1916. Thirty-seven active operators reported for the year.

GEORGIA.

Georgia was the fifteenth State in the value of clay products in 1916, which were reported by 64 operators.

The total value of clay products in Georgia was $2,361,982—brick and tile, $2,348,781; pottery, $13,201—an increase of $516,963. Georgia was seventh in output of common brick and thirteenth in value; it was sixth in value of sewer pipe. The principal product was common brick, valued at $1,050,473, an increase of $249,271; the quantity was 208,781,000 brick, an increase of 50,316,000. The value of common brick constituted 44 per cent of all clay products of the State. Sewer pipe ranked second in importance, being valued at $691,628, an increase of $124,510.

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Bibb County was the leading county in the production of common brick, though the value of the output of Richmond County was slightly larger. The production in Bibb County was 59,440,000 brick, valued at $251,760, an increase of 13,263,000 brick and of $54,694 in value. Richmond County's output was 48,896,000 brick, valued at $256,951, an increase of 22,742,000 brick and of $117,582 in value. Fulton County was also a large producer of common brick. Architectural terra cotta was reported only from Fulton County. Bibb County was the leading clay-working county and reported wares for 1916 valued at $516,713, an increase of $64,690. Fulton County was second and Richmond County third. The pottery industry of Georgia is of minor importance, only red earthenware and stoneware being made there.

ILLINOIS.

Illinois makes every variety of clay product as classified in this report except chemical pottery and china. It ranked fourth in value of all clay products in 1916, third in brick and tile products, and seventh in pottery. It was the leading State in output and value of common brick, and in value of architectural terra cotta; second in output and value of vitrified brick or block, and silica fire brick, and in value of stoneware; third in value of enameled brick; fourth in quantity and value of front brick, and in value of drain tile; fifth in value of sewer pipe and fireproofing; seventh in quantity and value of clay fire brick and sanitary ware. There were 225 operators who reported sales of clay products.

The total value of clay products in 1916 in Illinois was $17,633,351—brick and tile, $16,507,845; pottery, $1,125,506—or nearly 9 per cent of the total for the country, an increase of $2,841,413, or 19 per cent. The principal clay product of the State is common brick, the production of which was 1,182,473,000 brick, valued at $6,738,152, or $5.70 per thousand, an increase of 116,416,000 brick, but a decrease of $132,838 in value, owing to the lower price received. Of the common brick Cook County reported 833,164,000 brick, valued at $4,623,480, or $5.55 per thousand, an increase of 93,991,000 brick, but a decrease of $170,972 compared with 1915. Cook County produced 70 per cent of the common brick marketed in the State in 1916. This is the largest brick-making county in the country, and exceeded in 1916 the output and value of the New York portion of the Hudson River region by 130,568,000 brick and $71,012. Second in importance was vitrified brick or block, of which 175,989,000 were reported for 1916, valued at $2,465,179, an increase of 33,300,000 brick or block in quantity, and of $668,829 in value. The average price per thousand for vitrified brick or block increased $1.42 in 1916. Of this output 147,111,000 brick or block, valued at $2,217,951, or $15.08 per thousand, were used for paving, and 28,878,000 brick or block, valued at $247,228, or $8.56 per thousand, were used for other purposes. This was an increase of 27,703,000 brick or block in quantity and of $611,534 in value of those used for paving, and an increase of 5,597,000 brick or block and $57,295 in value of those used for other purposes. Knox County, in which Galesburg is situated, was the leading county in the production of vitrified brick or block, with Livingston County second, and Vermilion County third. Architectural terra cotta, the third product in value, produced most largely

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in Cook County, was reported to the value of $1,980,781, an increase of $690,933.

Front brick was made principally in Vermilion County and enameled brick was made only in Kankakee County. La Salle County was the principal producer of draintile, fireproofing, and clay fire brick. Sewer pipe was produced chiefly in McDonough County, and was the principal clay product of the county, though it is also a large producer of pottery—principally stoneware. Stoneware valued at $548,633 was the State's principal pottery product and was made chiefly in Warren and McDonough counties.

Cook County, owing to the large local market, Chicago, was the leading clay-working county in the State, and reported wares valued at $6,538,344, or 37 per cent of the State's total for 1916, an increase of $660,737. La Salle County was second, with production valued at $1,128,982, an increase of $192,487. Fire brick was the clay product of largest value in this county. Vermilion was third, with products valued at $1,099,526, principally common brick.

INDIANA.

Indiana is one of the most important clay-working States, ranking sixth in value of these products, which were reported by 199 operators in 1916. It was third in output and value of front brick and in value of draintile, of tile, not drain, and of sanitary ware; it was fourth in quantity and value of vitrified brick or block, and in value of fireproofing; fifth in value of white ware; sixth in quantity and value of clay fire brick; and seventh in value of sewer pipe.

The total value of Indiana's clay products was $9,667,313—brick and tile, $8,032,960; pottery, $1,634,353—an increase of $2,576,683, or 36 per cent, compared with 1915. Draintile was Indiana's principal clay product, valued in 1916 at $1,452,719, an increase of $198,914; its value constituted 15 per cent of the total for the State. Vigo County was the principal producer of draintile. Front brick, the clay product of second rank and made most largely in Clay County (valued at $1,192,076), showed an increase of $294,834 in value. The quantity reported for 1916 (116,860,000 brick) showed an increase of 33,250,000 brick. Sanitary ware valued at $1,140,455 was Indiana's third clay product. Common brick, the clay product of fourth importance (166,954,000 brick, valued at $963,932), showed an increase of 28,990,000 brick and of $161,708.

Lake County was the principal producer of common brick and was the second county in the value of all clay products. Clay County was the principal clay-working county and reported clay wares valued at $1,327,084, a small decrease from 1915. Sanitary ware is the principal pottery product of the State and showed an increase of $383,340, compared with 1915.

IOWA.

Iowa ranked ninth in value of clay products in 1916, the total value, exclusive of pottery, being $7,379,289, an increase of $635,674. Iowa was the leading State in value of draintile, the principal clay product of the State; third in value of fireproofing; eighth in value and ninth in quantity of vitrified brick or block; ninth in quantity and value of front brick; and ninth in value of sewer pipe. Drain-

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tile constituted 54 per cent of the State's total and was valued at $3,996,163, an increase of $193,564, compared with 1915. Fireproofing was the clay product of second importance in Iowa in 1916 and was valued at $1,141,291, an increase of $132,834. Common brick was third among Iowa's clay products and showed an increase of 6,924,000 brick in quantity and of $48,396 in value.

Cerro Gordo County was the leading producer of draintile and reported a value of $1,535,170, or considerably more than one-third of the State's total. Webster County was second, reporting draintile valued at $700,316, a small increase over 1915. Cerro Gordo was also the largest producer of fireproofing, reporting a value of $328,804, or more than a fourth of the total. Woodbury County was the largest producer of common brick, with Polk County second.

Cerro Gordo was the leading clay-working county and reported clay products valued at $1,943,530, an increase of $113,310; Webster County, whose principal product also is draintile, was second, with products valued at $1,332,411, an increase of $75,430; and Polk County, whose chief product was vitrified brick or block, was third, with $971,911, an increase of $180,540.

KANSAS.

Kansas ranked fourteenth in value of clay products in 1916, its 48 operators reporting wares valued at $2,747,803, an increase of $636,926, or 30 per cent. No pottery was reported from Kansas in 1916. Kansas was fifth in production and value of vitrified brick or block, fifth in production and seventh in value of front brick, and eighth in value of draintile and of fireproofing. The vitrified brick or block, the leading clay product of the State, marketed in 1916 amounted to 48,704,000, valued at $628,638, or $12.91 a thousand, an increase of 1,193,000 brick and of $20,039 in value, compared with 1915. Common brick, the clay product of second importance, showed an increase in both quantity and value, the former by 4,041,000 brick and the latter by $96,837.

The principal counties producing vitrified brick in Kansas, given in the order of the value of production, were Montgomery, Crawford, and Wilson. These three counties reported vitrified brick valued at $597,299, or 95 per cent of the State's total. Allen County was the largest producer of common brick, reporting 36,274,000 brick, valued at $174,556. Wilson County was second, reporting 31,988,000 brick, valued at $151,631.

Montgomery was the leading clay-working county, as in 1915, its products, valued at $847,681, or 31 per cent of the State's total, showed an increase of $202,618. Montgomery County's leading clay products were vitrified brick or block, front brick, retorts and condensers, fireproofing, and tile, not drain. Wilson County was second, with products valued at $654,767. These two counties reported considerably more than half of the value of Kansas clay products.

KENTUCKY.

Kentucky ranked eleventh in value of clay products in 1916, rising from twelfth in 1915 and displacing Michigan. The value of Kentucky's clay products in 1916 was $3,559,257—brick and tile, $3,438,146; pottery, $121,111—an increase of $1,117,967, or nearly

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46 per cent, compared with 1915. Kentucky's principal clay product is fire brick, in which it ranked fourth. It was fifth in value of tile, not drain, and ninth in draintile. Its output of fire brick was valued at $2,323,606, an increase of $997,802, or 75 per cent. The quantity of 9-inch equivalent fire brick marketed in Kentucky was 114,945,000 brick, an increase of 37,775,000 brick. The value of fire brick constituted 65 per cent of the value of Kentucky's clay products. Common brick was second in importance, 70,610,000 brick being reported, valued at $464,775, a decrease of 4,197,000 brick and of $14,731. Tile not drain, valued at $295,815, an increase of $90,631, was third in value. Kentucky's production of pottery, mostly stoneware, was valued at $121,111, an increase of $12,272.

Carter County is the chief producer of fire brick and reported 73,157,000 9-inch equivalent brick, valued at $1,505,336, or about 65 per cent of the output and value of fire brick of the State, an increase of 24,518,000 brick and of $655,095. Fire brick was the only clay product made in Carter County. Boyd County was second in value of fire brick but third in output, and Jefferson County was second in output and third in value. Jefferson County was the leading county in the production and value of common brick, reporting 18,092,000 brick, valued at $112,330, a decrease of 2,984,000 brick and of $19,233 from 1915.

The pottery products of Kentucky consisted of red earthenware and stoneware, made most largely in Jefferson and McCracken counties.

Carter County was the leading county in the value of clay products in 1916, Jefferson being second, with wares valued at $641,396, an increase of $149,847. These two counties reported 60 per cent of the total value of clay products in the State in 1916. Boyd County was third.

MARYLAND.

Maryland ranked twentieth in value of clay products in 1916. Forty-three operators reported wares valued at $1,825,870—brick and tile, $1,548,295; pottery, $277,575—an increase of $249,414, or nearly 16 per cent, compared with 1915. Maryland ranked fifth in value of enameled brick, eighth in white ware and sanitary ware, and tenth in value and eleventh in quantity of fire brick. Maryland's clay product of greatest value was common brick, valued at $871,866, an increase of $37,737. The quantity of common brick marketed in Maryland was 119,650,000, an increase of 3,836,000. The value of common brick constituted 48 per cent of the value of all of Maryland's clay products. Fire brick was the second clay product, 17,724,000 9-inch equivalent brick being reported, valued at $412,832, or $23.29 per thousand, an increase of 5,916,000 brick, and of $186,742 in value, and of $4.14 in price per thousand.

Maryland ranked eleventh in the value of pottery in 1916, white ware being its principal pottery product. Red earthenware, sanitary ware, and porcelain electrical supplies were also reported. The chief center of production of common brick was Baltimore City and Baltimore County. These two localities reported 93,032,000 common brick, valued at $678,567, or 78 per cent of the quantity and value for the State. This was an increase of 9,648,000 brick and of $77,577. Allegany County was the leading county producing fire

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brick, reporting 16,129,000 9-inch equivalent fire brick valued at $364,691, or 91 per cent of the output and 88 per cent of the value for the State.

Baltimore City and Baltimore County constituted the principal clay-working center of the State and reported products valued at $1,040,586, or 57 per cent, of the State total for 1916, an increase of $40,329. Baltimore County was the leading county, with wares valued at $647,298, and Allegany County was second, with wares valued at $590,309. Allegany County's principal clay products were fire brick and sanitary ware.

MASSACHUSETTS.

Massachusetts ranked nineteenth in 1916 in value of clay products, which were reported by 56 operators. The value of its clay products was $1,892,558—brick and tile, $1,661,737; pottery, $230,821—an increase of $308,954, or nearly 20 per cent. It was the leading State in value of stove lining, third in red earthenware, and eleventh in common brick. The chief clay product of Massachusetts is common brick, which was valued in 1916 at $1,207,777, or 64 per cent of the value of all clay products of the State. The quantity reported was 140,420,000 brick. This was an increase of $181,598 in value, but a decrease of 4,100,000 brick. The average price per thousand increased $1.50 compared with 1915, or to $8.60. Stove lining was second among the clay products of Massachusetts, being valued at $180,482 in 1916, an increase of $18,687. This State reported 30 per cent of the value of stove lining—made principally in Bristol County—for the entire country in 1916. Red earthenware is the principal pottery product of the State; stoneware, chemical pottery and white ware were also reported.

Middlesex County was the leading county in quantity and value of common brick, with Hampden County second and Plymouth third. Middlesex County was also the leading clay-working county, reporting wares valued at $512,787, or 27 per cent of the production of the State. This was an increase of $129,685 over 1915.

MICHIGAN.

Michigan ranked twelfth in value of clay products in 1916, and these wares were reported by 78 operators to the amount of $3,497,770—brick and tile, $2,705,054; pottery, $792,716—an increase of $727,713, or 26 per cent. Michigan was fifth in value of draintile and porcelain electrical supplies, sixth in common brick, and seventh in white ware.

Michigan's leading clay product is common brick. In 1916 279,175,000 common brick were reported, valued at $1,856,587, an increase of 1,776,000 brick and of $395,399 in value. The value of common brick was 53 per cent of the value of all clay products in the State in 1916. Draintile ranked second in importance and was reported to the value of $548,795, an increase of $243,639, or 80 per cent. Michigan's chief pottery product was porcelain electrical supplies; red earthenware, chemical pottery, white ware, and sanitary ware were also produced in 1916.

Wayne County, in which Detroit is located, led in the production of common brick, reporting 226,966,000 brick, valued at $1,515,714,

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or 81 per cent of the production of common brick for the State, an increase of 1,951,000 brick and of $356,098 over 1915. Wayne County was the third largest common brick producing center of the country in 1916. It was the leading clay-working county in the State, reporting wares valued at $2,066,167, or 59 per cent of the total, and an increase of $534,815 over 1915. Eaton County, the second in value of all clay products, is the principal draintile-producing county, and draintile was its principal clay product. Porcelain electrical supplies are produced only in Wayne County and white ware in McComb County.

MINNESOTA.

The value of clay products in Minnesota in 1916, exclusive of pottery, was $2,064,362, an increase of $418,449, or more than 25 per cent. Minnesota ranked sixth in value of draintile and tenth in sewer pipe and front brick. The principal clay product is common brick, of which 118,090,000 brick, valued at $772,696, were reported, an increase of 10,617,000 brick and of $97,550 in value. The value of common brick constituted 37 per cent of all of Minnesota's brick and tile products. Draintile was second, valued at $422,809, an increase of $167,462.

Carver County was the largest producer of common brick, with Carlton County second and Hennepin third.

Goodhue was the leading clay-working county in the State, Hennepin was second, and Carver third.

MISSOURI.

Missouri is one of the most important clay-working States, ranking seventh in the value of clay products in 1916 from ninth in 1915. It reported every variety of brick and tile as classified in this report. Eighty-three operators reported sales of clay products. It was second in value of sewer pipe and enameled brick, third in fire brick (quantity and value), fifth in value of front brick and architectural terra cotta, and seventh in vitrified brick or block and draintile.

The total value of clay products of Missouri in 1916 was $7,640,995—brick and tile, $7,634,559; pottery, $6,436—an increase of $2,209,426, or nearly 41 per cent. Fire brick is the chief product, 126,257,000 9-inch equivalent clay fire brick, valued at $3,006,841, being reported, an increase of 26,312,000 brick and of $1,084,103 in value. The value of the clay fire brick constituted 39 per cent of the total of clay products of the State. Sewer pipe was second in value, $1,308,977, an increase of $296,640. Common brick was third, valued at $896,201, a small decrease from 1915. The quantity of common brick also showed a small decrease from 1915.

Red earthenware and stoneware are the only pottery products reported from Missouri.

St. Louis City led in quantity and value of clay fire brick in 1916, reporting 44,884,000 9-inch equivalent brick, valued at $1,202,237. This was an increase of 14,173,000 brick and of $455,313 in value. St. Louis County was second, with 35,550,000 brick, valued at $950,668, a decrease of 2,472,000 brick, but an increase of $240,756 in value. These two localities produced 64 per cent of the quantity of fire brick of the State and 72 per cent of its value. They also led

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in the production of common brick, St. Louis City reporting 55,767,000 common brick, valued at $370,198, and St. Louis County 25,305,000 brick, valued at $150,664, and both showing a small decrease from 1915. These two localities reported 64 per cent of the quantity of common brick for the State. St. Louis City is also the leading producer of every other variety of brick and tile except fireproofing and stove lining. It was the only producer in the State of fancy and enameled brick, terra cotta, tile, not drain, and silica brick. Jackson and Henry counties were the principal producers of fireproofing. Audrain County was the only producer of stove lining.

St. Louis City is the leading clay-working district in the State, and reported wares valued at $3,971,496, or 52 per cent of the State total, an increase of $1,087,371 compared with 1915. St. Louis County was second with wares valued at $1,202,094, or 16 per cent of the State total, an increase of $237,571. Audrain County was third, Jackson fourth, and Henry fifth.

NEW JERSEY.

New Jersey ranks third in value of clay products. It reported for 1916 every variety of clay product, as classified in this report, except vitrified brick or block. It was second in value of pottery and fourth in value of brick and tile. It was first in value of china, sanitary wares, and enameled brick; second in architectural terra cotta, fireproofing, tile, not drain, porcelain electrical supplies, and chemical pottery; fourth in white ware and stove lining; fifth in common brick and fire brick; and sixth in front brick.

The value of New Jersey's clay products in 1916 was $20,814,402; brick and tile, $9,749,524; pottery, $11,064,878, an increase of $4,848,984, or 30 per cent, compared with 1915. The increase in brick and tile was $1,833,444 and in pottery $3,015,540. New Jersey's leading clay product is sanitary ware, valued at $6,458,356, an increase of $1,664,950. This ware constituted 31 per cent of the total value of the clay products for the State. Common brick was second, valued at $2,366,614, an increase of $266,960. The quantity of common brick reported was 328,419,000 brick, a decrease of 25,685,000 brick. The average price per thousand increased $1.28, or to $7.21. Fireproofing ranked third, valued at $1,830,949, an increase of $441,829. Terra cotta was fourth, valued at $1,818,052, an increase of $387,084. Porcelain electrical supplies was fifth, valued at $1,674,093, an increase of $645,101. China, tile, not drain, and fire brick are also important products in this State, being valued at $1,407,930, $1,298,392, and $1,162,794, respectively, large gains in 1916 over 1915. There were 144 operators reporting sales for 1916.

Mercer County, in which Trenton is located, is the most important clay-working county in the State, and its leading product is sanitary ware, which was reported in 1916 to the value of $5,342,085, or 26 per cent of the State's total for all clay products, and an increase of $1,339,567. The value of all of Mercer County's clay products was $9,644,892—brick and tile, $479,214; pottery, $9,165,678—or 46 per cent of the State's total, an increase of $2,608,629, principally pottery. Mercer County leads in the production of every variety of pottery except red earthenware and stoneware, none of which is produced in that county. It was the only producer in the State of china and

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white ware. Middlesex County was second in importance as a clay-working center, its production being valued at $7,846,362—brick and tile, $6,880,263; pottery, $966,099—or 38 per cent of the State's total, an increase of $1,460,173. Middlesex County was the leading producer of every variety of brick and tile reported except front brick, and was the only producer of enameled brick, stove lining, and silica fire brick. Camden County was the leading producer of front brick.

NEW YORK.

New York ranked fifth in value of clay products, its 186 operators in 1916 reporting every variety of wares as classified in this report except fancy brick, enameled brick, and silica brick. It ranked fifth in value of brick and tile and fourth in pottery. This State has been long famous for the large production of common brick along Hudson River, the chief source of supply of common building brick for Greater New York, which consumes annually an enormous quantity of this material. New York was the second State in quantity and value of common brick, Illinois being first. It was also second in value of china, third in value of architectural terra cotta, stove lining, and porcelain electrical supplies, sixth in white ware, and ninth in fireproofing and fire brick.

The value of clay products in New York in 1916 was $11,755,012—brick and tile, $8,410,340; pottery, $3,344,672—an increase of $2,266,010, or nearly 24 per cent, compared with 1915. Common brick is New York's principal clay product, and 977,085,000 common brick, valued at $6,433,266, were marketed in 1916, a decrease of 3,495,000 brick but an increase of $1,275,589 in value, compared with 1915. The average price per thousand for common brick increased $1.32, or to $6.58. Nearly three-fourths of the common brick came from the Hudson River region. The value of common brick constituted 55 per cent of all of New York's clay products in 1916. Porcelain electrical supplies ranked second and were valued at $1,623,433, an increase of $470,365; china was third, valued at $1,254,374, an increase of $421,073; terra cotta was fourth, valued at $714,041, an increase of $66,225; fire brick was fifth, valued at $417,805, an increase of $77,654.

Ulster County was the leading county in the production of common brick followed by Rockland, Saratoga, Dutchess, Orange, and Albany.

New York's principal pottery product is porcelain electrical supplies; china was the second pottery product. White ware is also produced in considerable quantity.

Onondaga County, owing to its large production of pottery, was the leading county in the State in value of clay products in 1916, as for several years, and reported wares valued at $1,630,587—pottery, $1,464,327; brick and tile, $166,260—an increase of $352,679. Ulster, whose only clay product is common brick, was second in value—$1,444,275—Erie was third, Rockland fourth, and Kings fifth. Onondaga, Ontario, and Schenectady counties are the principal producers of porcelain electrical supplies, and together they reported a production valued at $1,224,042, or 75 per cent of the State's total for this variety, and an increase of $304,315.

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NORTH CAROLINA.

The value of clay products in North Carolina, the twenty-fourth State in rank, in 1916 was $1,551,436—brick and tile, $1,541,576; pottery, $9,860—an increase of $461,501, or 42 per cent, compared with 1915. The chief clay product of North Carolina is common brick, of which 193,264,000 were reported, valued at $1,234,926, an increase of 53,007,000 brick and of $372,535 in value. The value of common brick constituted 80 per cent of all of North Carolina's clay products. Front brick, draintile, and fireproofing were also made in small quantities; sewer pipe was made in considerable quantity by less than three producers.

Chatham County was the leading producer in quantity of common brick; in value of common brick, however, Wayne County was first. There were less than three producers of common brick in Chatham County and figures can not be given.

Wayne County reported 21,300,000 brick, valued at $142,000, an increase of 10,053,000 brick and of $74,000. Chatham County was second in value of common brick, and Gaston County was third, as in 1915.

Guilford County is the principal clay-working county in the State, and reported in 1916 products valued at $314,255, an increase of $82,442. Common brick, draintile, sewer pipe, fireproofing, and flue lining were reported from this county. Wayne County was second in the value of clay products.

OHIO.

Ohio was the leading State in the Union in value of clay products in 1916, as for many years. It was first in pottery and second in brick and tile, its output being reported by 500 operators. Every variety of clay product, as classified in this report, was reported except enameled brick, architectural terra cotta, and china. It was the leading State in vitrified brick or block, fancy or ornamental brick, sewer pipe, fireproofing, tile (not drain), red earthenware, stoneware, chemical pottery, white ware, and porcelain electrical supplies; second in front brick, draintile, and fire brick; and fourth in common brick and in value of silica fire brick and sanitary ware.

The value of its clay products in 1916 was $44,947,877—brick and tile, $25,506,344; pottery, $19,441,533—nearly 22 per cent of the total for the country, an increase of $8,108,256, or 22 per cent, compared with 1915. The increase in Ohio's brick and tile was $4,596,502, and in pottery $3,511,754. Ohio's principal clay product is white ware valued at $11,834,913, or 26 per cent of the State total, an increase of $1,650,079. Sewer pipe ranked second in value, $5,132,810, an increase of $1,413,020. Vitrified brick or block was third, valued at $3,522,695, a decrease of $495,063. The quantity of vitrified brick reported was 295,048,000 brick or block, a decrease of 38,240,000 brick or block. Of this output 250,885,000 brick or block, valued at $3,139,520, or $12.51 per thousand, was sold for paving, and 44,163,000 brick or block, valued at $383,175, or $8.68 per thousand, was sold for other purposes. The fourth product was clay fire brick, valued at $3,337,470, an increase of $1,340,678, or 67 per cent. Common brick was fifth, with an increase of $477,497. Common brick was followed in order by fireproofing, tile, not drain, porcelain

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electrical supplies; front brick, stoneware, and draintile, each of which was valued at more than $1,000,000.

Porcelain electrical supplies, valued at $2,181,026, was Ohio's second pottery product, displacing stoneware, valued at $1,938,726, which became third. This change in relative rank, however, is probably due to the fact that for 1916 chemical pottery was separately classified, which probably took enough from stoneware to put it in third place.

Sewer pipe was produced most largely in Summit, Tuscarawas, and Jefferson counties in the order named, these three counties reporting 87 per cent of the total for the State. The leading county in vitrified brick or block was Stark, with Cuyahoga second, Athens third, and Scioto fourth. Cuyahoga was the leading county in common brick in 1916, and reported 133,304,000 brick, valued at $1,098,415, or 30 per cent of the quantity and 36 per cent of the value of common brick for the State, a decrease of 13,820,000 brick but an increase of $202,079 in value, compared with 1915. The average price per thousand increased $2.15, or to $8.24. The city of Cleveland furnishes the principal market for this product. Lucas County was second, reporting 43,165,000 common brick, valued at $300,288. Columbiana County is the principal clay-working county in Ohio. The clay products of this county in 1916 were valued at $8,802,268—pottery, $8,164,204; brick and tile, $638,064—or 20 per cent of the State's total for all clay products, an increase of $1,518,498. The value of white ware, its chief clay product, was $6,873,459, or 58 per cent of the State total for this variety of ware. The value of pottery in this county constituted 42 per cent of all pottery in the State. Muskingum, the second county in the value of clay products, reported wares valued at $4,419,554—brick and tile, $2,388,052; pottery, $2,031,502—or 10 per cent of the State's total for all clay products, an increase of $622,220. Muskingum's principal brick and tile product was tile (not drain), and its principal pottery product was stoneware. Summit County was third with wares valued at $4,366,282—brick and tile, $2,724,520, principally sewer pipe; pottery, $1,641,762—an increase of $1,045,895. Mahoning County reported wares valued at $2,950,667—brick and tile, $291,065; pottery, $2,659,602—an increase of $79,294. Its chief pottery product was white ware, valued at $2,527,602, and its principal brick and tile product was front brick. Tuscarawas County was fifth, with wares valued at $2,731,346, an increase of $812,066. Sewer pipe is its chief clay product, though fire brick and front brick are also made there in considerable quantities. Jefferson County was sixth in value of clay products, with wares valued at $2,654,656. Sewer pipe, valued at $1,238,750, was its chief clay product.

PENNSYLVANIA.

Pennsylvania ranked second in value of clay products and reported in 1916 every variety of ware as classified in this report except enameled brick. It was first in value of brick and tile, displacing Ohio, and fifth in pottery. Its output was reported by 348 operators. It was first in front brick, clay fire brick, and silica fire brick; second in fancy brick, stove lining, and red earthenware; third in common

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brick, vitrified brick or block, sewer pipe, white ware, and china; fourth in architectural terra cotta, tile, not drain, and stoneware.

Pennsylvania's clay products were valued at $32,110,690—brick and tile, $29,630,563; pottery, $2,480,127—an increase of $9,384,659, or 41 per cent, compared with 1915. This total was 15 per cent of the value of all clay products of the country.

The clay product of greatest value is fire brick. Silica fire brick included, Pennsylvania marketed in 1916, 681,821,000 9-inch equivalent fire brick, valued at $15,200,354, or $22.29 per thousand, an increase of 210,431,000 brick and of $6,111,404 in value compared with 1915. Pennsylvania reported 515,530,000 9-inch equivalent clay fire brick, valued at $11,009,646, or $21.36 per thousand, an increase of 136,488,000 brick and of $3,832,017, and it reported 166,291,000 9-inch equivalent silica fire brick, valued at $4,190,708, or $25.20 per thousand, an increase of 73,943,000 brick and of $2,279,387. Pennsylvania reported half the fire brick marketed in 1916 in the entire country, and its value was nearly one-half (49 per cent) of the value of all fire brick. Fire brick constituted 47 per cent of the State's total value for all clay products. Common brick was second in value. The quantity reported was 688,096,000 brick, valued at $5,200,910, or $7.56 a thousand, an increase of 10,805,000 brick and of $685,614 in value. Pennsylvania's third clay product was front brick, 277,612,000 brick, valued at $3,076,024, being reported, an increase of 32,831,000 brick and of $444,229. Vitrified brick or block was fourth in importance, 118,664,000 brick or block being reported, valued at $1,495,645, a decrease of 5,690,000 brick or block and of $142,873 in value. Of this output 93,077,000 brick or block, valued at $1,278,837, or $13.74 per thousand, was sold for paving, and 25,587,000 brick or block, valued at $216,808, or $8.47 per thousand, was sold for other purposes. This was a decrease of 19,316,000 brick or block used for paving but an increase of 13,626,000 brick or block used for other purposes. Sewer pipe was fifth, valued at $1,207,016, an increase of $203,103.

White ware is Pennsylvania's pottery product of greatest value, followed by china, sanitary ware, porcelain electrical supplies, stoneware, and red earthenware.

Philadelphia County, the fourth largest common-brick center of the country, with the city of Philadelphia as a market, is the principal producer of common brick in the State, and reported 188,864,000 brick, valued at $1,502,889, a decrease of 16,958,000 brick, but an increase of $116,902 in value in 1916 compared with 1915. The average price per thousand increased in this county $1.23, or to $7.96. Allegheny County, the home of Greater Pittsburgh, was second, with 94,228,000 brick, valued at $721,674, an increase of 762,000 brick and of $75,103 in value. Lawrence County was the principal vitrified brick or block producing county, with Beaver second, and Fayette third. Front brick is made chiefly in Armstrong County, 85,539,000 brick, valued at $1,004,110, or nearly one-third of the production and value of the State, having been reported from that county, an increase of 9,621,000 brick and of $161,725. Clearfield County is the largest producer of clay fire brick, and reported 178,970,000 9-inch equivalent brick, valued at $3,969,565, or more than one-third of the production of the State, an increase of 75,671,000 brick and of $1,971,627. Clinton County was also a large producer, reporting 61,835,000

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9-inch equivalent brick valued at $1,448,787. Huntingdon County is the largest producer of silica fire brick and reported 89,270,000 9-inch equivalent brick for 1916, valued at $2,321,248, or considerably more than half the production of the State, an increase of 37,025,000 brick and of $1,217,160, compared with 1915.

Clearfield County ranked first in the value of clay products in 1916, with wares valued at $4,461,802, an increase of $1,989,503 compared with 1915. Fire brick is Clearfield's principal clay product, but vitrified brick and front brick are also made there in large quantities. Allegheny County was second, with products valued at $2,765,408 (an increase of $759,408), displacing Philadelphia County, which was third, with wares valued at $2,333,930 (an increase of $281,831). Fire brick (valued at $757,746) was Allegheny's chief clay product, followed closely by common brick. Philadelphia County's principal clay product was common brick. Terra cotta and fire brick are also important products of the county.

TENNESSEE.

The total value of Tennessee's clay products in 1916 was $1,983,957—brick and tile, $1,679,319; pottery, $304,638—an increase of $435,737, or 28 per cent, compared with 1915. Tennessee ranked seventeenth among the clay-working States, rising from nineteenth in 1915. Sixty-six operators reported sales. Its principal clay product is common brick, of which 161,761,000 brick were reported, valued at $1,004,234, an increase of 48,757,000 brick and of $349,140 in value. Common brick constituted 51 per cent of the value of all clay products of the State. Tennessee's principal pottery product is turpentine cups—of which it is the leading producer—made in Hamilton County.

Davidson County, in which Nashville is located, was the leading producer in quantity of common brick in 1916, and reported 39,323,000 brick. It was followed by Hamilton, with 36,072,000 brick, and Sullivan, with 32,348,000 brick. In value of this brick, however, the ranks were reversed; Sullivan ranked first ($227,575), Hamilton second ($221,551), and Davidson third ($212,877). These three counties reported two-thirds of the common brick in the State in 1916.

Hamilton County was the principal clay-working county in the State, its production being valued at $827,809, or 42 per cent of the State's total, an increase of $210,719; Davidson County was second, with products valued at $319,395; and Sullivan County was third. Hamilton County's principal clay products were common brick, sewer pipe, and turpentine cups. Davidson's principal products were common brick and front brick.

TEXAS.

Texas ranked thirteenth in value of clay products in 1916, rising from fourteenth in 1915. Its 86 operators reported wares valued at $2,837,960—brick and tile, $2,749,780; pottery, $88,180—an increase of $861,070, or nearly 44 per cent, compared with 1915. It was seventh in value of fireproofing and in quantity of front brick; eighth in value of front brick and sewer pipe; and ninth in quantity and tenth in value of common brick. Common brick is its principal clay product, 203,013,000 brick, valued at $1,224,919, being reported, an

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increase of 55,544,000 brick and of $396,533 in value, compared with 1915. The value of common brick constituted 43 per cent of the value of all clay products of the State. Sewer pipe ranked second, front brick third, and fireproofing fourth.

Ellis County was the largest producer of common brick, reporting 53,306,000 brick, valued at $282,537, an increase of 6,685,000 brick and of $54,882. Wilson County, whose principal clay product is sewer pipe, was the leading county in the value of clay products.

VIRGINIA.

The total value of Virginia's brick and tile products in 1916 was $1,676,723, an increase of $228,921, or nearly 16 per cent, compared with 1915. Virginia ranked twenty-second among the clay-working States, its wares having been reported by 56 operators. It was eighth in common brick, of which 204,808,000 brick, valued at $1,397,436, were reported, an increase of 18,159,000 brick and of $181,877. Common brick constituted more than 80 per cent of the State's clay products. Front brick is the only other clay product of importance in Virginia; it was valued at $232,135, an increase of $39,692.

Virginia's pottery products in 1916 were tobacco pipes and sanitary ware, the former being made in Appomattox County and the latter in Rockingham County.

Henrico was the leading county in common brick, reporting 43,301,000 brick, valued at $304,235, an increase of 4,157,000 brick and of $47,979 in value. The average price per thousand increased in this county 48 cents, or to $7.03. Alexandria County was second, reporting 38,113,000 brick, valued at $263,665, an increase of 3,503,000 brick and of $33,427 in value. The average price per thousand in this county was $6.92, an increase of 27 cents. Front brick was made most largely in Alexandria County.

Alexandria County was the leading clay-working county in the State in 1916 and reported wares valued at $489,162, an increase of $73,479.

WASHINGTON.

Washington ranked twenty-third in the value of brick and tile products in 1916, with wares valued at $1,589,574, an increase of $135,138, compared with 1915. Washington ranked seventh in value of architectural terra cotta, ninth in value and tenth in quantity of vitrified brick or block, and eleventh in value of sewer pipe. Sewer pipe was the most important clay product, being valued at $347,388, an increase of $28,991. Vitrified brick or block was second, valued at $322,182, common brick third, and terra cotta fourth.

King County, with Seattle and Tacoma for markets, is the principal producer of common brick and reported 19,635,000 brick, or 43 per cent of the State's output, valued at $122,152, or 40 per cent of the total value for this variety, an increase of 1,013,000 brick and of $12,503 in value. King was also the leading county in draintile, sewer pipe, and terra cotta, and was the leading clay-working county, reporting wares valued at $861,251, or 54 per cent of the State's total, an increase of $35,386. Spokane County, whose principal product was sewer pipe, was second, with wares valued at $273,900, an increase of $33,794,

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WEST VIRGINIA.

West Virginia ranked eighth in value of clay products in 1916, 61 operators reporting sales. It was third in pottery and sixteenth in brick and tile. It was second in value of white ware and sanitary ware, fourth in china and porcelain electrical supplies, and sixth in vitrified brick or block and tile, not drain. The value of its clay products in 1916 was $7,634,321—brick and tile, $1,853,468; pottery, $5,780,853—an increase of $1,349,794, or more than 21 per cent, compared with 1915. The increase was principally in pottery—$1,270,230; brick and tile, $79,564. West Virginia's principal clay product is white ware, valued at $3,576,510, or 47 per cent of the State's total, an increase of $738,744. Sanitary ware was second, valued at $1,310,949, an increase of $254,364. Vitrified brick or block was third, valued at $579,679, a decrease of $261,388; common brick was fourth, valued at $420,955, a decrease of $24,888.

Hancock County was the leading producer of vitrified brick or block and reported 37,451,000 brick or block, valued at $457,079, or 81 per cent of the output and 79 per cent of the value for the State. This was a decrease of 13,829,000 brick or block and of $165,397 in value.

Hancock is the leading clay-working county in the State, its production in 1916 being valued at $3,711,243, or 49 per cent of the State's total, an increase of $449,704. Of this production $3,015,380 was pottery, principally white ware, and $695,863 was brick and tile, principally vitrified brick or block. More than half of the State's output of pottery and three-eighths of its brick and tile in 1916 were produced in Hancock County.

CLAY.

GENERAL CONDITIONS.

Clay available for the manufacture of clay products is one of the most widely distributed minerals. Hence there are clay-working plants scattered over every State in the Union. Miners of the lower-grade clays are usually also the manufacturers, but as the higher grades of ware are reached the rule is that fewer and fewer manufacturers are also miners, until in the highest grades of ware the manufacturer usually buys and does not mine the clays he uses. The figures given in the following tables represent clay that is mined and not burned into clay products by the miner, but is sold as clay. The clay thus sold is small in quantity compared with the total production and includes mainly clay used for high-grade pottery and tile, for paper making, and for refractory products.

The condition of the clay-mining industry in 1916 showed considerable progress; the marketed production shared the general prosperity of the country and made a large increase. This was especially true of the fire-clay industry, which made the greatest gain in both quantity and value, compared with 1915. The clay-mining industry, in common with others, suffered from scarcity of labor and difficulty of transportation, which helped to curtail output.

The embarrassment caused the manufacturers of high-grade wares, especially refractories and other wares that require highly plastic clay—such as glasshouse pots and supplies, crucibles, lead pencils,

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abrasive wheels, and oilcloth—was felt more keenly than ever during 1916, by reason of the practical cessation of imports from Europe of high-grade fire clay. Consequently the demand for domestic substitutes was greatly increased, and the Geological Survey has been able to act as an intermediary between producers and users of these clays. The Bureau of Standards, Department of Commerce, has made a laboratory study of the subject [1] and as a result it is suggested that, although there seems to be no reason to think that such clays can not be found in the United States, yet it is believed the best solution of the problem would probably be to depend on a mixture of two or more clays representing both those of the open and more refractory and those of the dense and vitrifying variety, such as the well-known clays of the St. Louis region and the ball clays of Tennessee and Kentucky or the plastic fire clays of Ohio and Pennsylvania. A more recent demand has been for clays suitable for making glasshouse pots for use in making optical glass, one of the principal requisites of which is that the clay be practically free from iron.

Imported kaolin comes principally from England. The uncertain deliveries and increasing cost of the imported material to the consumer in this country, owing to the increase in ocean freights, has created an unusual demand for domestic kaolin, notwithstanding the increase in imports, and the Bureau of Mines has shown [2] that by proper treatment the sedimentary kaolins of Georgia and South Carolina can be made available as a substitute for imported kaolin.

The imports of clay, which decreased in 1915, increased in 1916 in both quantity and value but, with the exception of 1915, were the smallest in quantity and value since 1909 and were less by 99,234 tons and $783,185 than the maximum of 1914.

PRODUCTION.

The clay sold as such in 1916 amounted to 2,932,590 short tons, an increase of 569,636 tons, or 24 per cent. This clay was valued at $5,751,774, or $1.96 per ton, an increase of $1,779,833, or 45 per cent, and of 28 cents in the average price. Every variety of clay except brick clay increased in quantity and value, and paper clay, ball clay, and fire clay reached their maximum quantity and value in 1916. Fire clay made the largest gain in production, 487,333 tons, or 31 per cent; paper clay increased 40,401 tons; kaolin, 19,692 tons; ball clay, 14,413 tons. Slip clay, which has been declining in production since 1912, made a large increase in output, 6,418 tons, or 84 per cent, in 1916, compared with 1915. Fire clay showed the largest increase in value, $1,346,527, or 57 per cent; paper clay increased $229,289, or 42 per cent; slip clay, $29,165, or 155 per cent; kaolin, $65,299, or 27 per cent; and ball clay, $89,242, or 30 per cent. Brick clay decreased 4,804 tons and $17,009. Fire clay is the chief kind, judged by production, and constituted 70 per cent of the quantity and 64 per cent of the value of the clay marketed in 1916. Paper clay ranked second in value of output, and ball clay third. The average price per ton varied but little in 1916, compared with 1915. The greatest

[1] Bleininger, A. V., and Schurecht, G. H., Properties of some European plastic fire clays: Bur. Standards Tech. Paper 79, 1916.

[2] Sproat, I. E., Refining and utilization of Georgia kaolins, with a preface by C. L. Parsons: Bur. Mines Bull. 128, 1916.

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changes were in slip clay, which advanced 95 cents, and in kaolin, which decreased $2.19 owing to a comparatively large product from Maryland which was marketed at a very low price, $1.33 per ton.

Clay marketed in the United States, 1905–1916.

Year.	Kaolin.		Paper clay.		Slip clay.		Ball clay.		Fire clay.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1905	44,675	$326,835	76,339	$307,238	24,565	$33,384	61,345	$167,212	1,229,647	$1,529,468
1906	51,937	369,452	75,963	342,708	21,427	31,546	54,173	199,073	1,380,472	1,878,011
1907	47,645	340,311	66,191	293,943	20,325	37,925	52,413	195,515	1,474,462	2,054,698
1908	28,649	216,243	64,510	310,943	10,087	22,370	40,838	133,770	1,101,579	1,486,139
1909	31,227	241,060	81,586	386,764	18,010	30,527	49,074	214,194	1,463,919	2,082,193
1910	34,221	255,873	85,949	420,476	17,696	29,962	70,637	257,265	1,638,931	2,157,720
1911	27,400	221,045	99,265	454,435	8,393	16,770	65,072	220,710	1,526,921	2,112,827
1912	25,852	220,747	119,857	522,924	16,339	27,573	64,939	227,545	1,695,337	2,363,357
1913	28,834	235,457	126,377	567,977	10,902	24,505	67,134	237,672	1,820,379	2,592,591
1914	34,191	284,817	116,328	558,334	8,237	17,731	67,927	255,767	1,409,467	2,147,277
1915	28,031	241,520	113,033	539,622	7,646	18,774	75,348	301,910	1,570,481	2,361,482
1916	47,723	306,819	153,434	768,911	14,064	47,939	89,761	391,152	2,057,814	3,708,009

Year.	Stoneware clay.		Brick clay.		Miscellaneous clay.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1905	181,485	$219,767	(a)	(a)	188,077	$184,102	1,806,133	$2,768,006
1906	146,861	150,774	(a)	(a)	296,619	273,692	2,027,452	3,245,256
1907	125,060	136,576	136,515	$112,003	261,068	277,577	2,183,679	3,448,548
1908	124,192	102,390	210,556	154,575	143,490	173,556	1,723,901	2,599,986
1909	130,757	137,264	222,686	171,183	162,388	186,522	2,159,647	3,449,707
1910	152,942	153,044	173,625	128,039	215,228	223,106	2,389,229	3,625,485
1911	151,384	165,751	142,020	123,900	162,243	165,325	2,182,698	3,480,763
1912	124,409	115,522	229,306	204,504	254,226	263,848	2,530,265	3,946,020
1913	153,353	143,587	158,890	137,976	282,120	240,694	2,647,989	4,180,459
1914	130,383	116,610	199,154	161,852	244,173	214,180	2,209,960	3,756,568
1915	134,297	126,429	101,968	93,863	332,150	288,341	2,362,954	3,971,941
1916	135,958	137,779	97,164	76,854	336,672	314,311	2,932,990	5,751,774

a Included in "Miscellaneous."

The maximum, both in quantity and value, of clay marketed in the period covered by this table was attained in 1916. The previous year of greatest output and value was 1913. The quantity of clay sold in 1916 exceeded that of 1913 by 284,601 tons, or 11 per cent, and its value was greater by $1,571,315, or 38 per cent. Kaolin reached its maximum production and value in 1906, the output of 1916 being less than that of 1906 by 4,214 tons and its value less by $62,633.

Slip clay reached its maximum quantity in 1905 and its maximum value in 1916. Brick clay reached its maximum quantity and value in 1912, since which time it has been decreasing and reached its minimum quantity and value in 1916.

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Clay marketed in the United States in 1915.

State.	Kaolin.		Paper clay.		Slip clay.		Ball clay.		Fire clay.		Stoneware clay.		Brick clay.		Miscellaneous clay.[a]		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama									31,520	$34,882					(b)	(b)	31,870	$35,232
Arkansas									(b)	(b)							(b)	(b)
California	(b)	(b)					(b)	(b)	52,817	69,885	8,900	$8,475	18,170	$17,423	13,625	$14,528	94,598	118,130
Colorado									20,011	40,234			49,739	26,282	1,363	1,664	71,113	68,180
Connecticut													(b)	(b)			(b)	(b)
Delaware	6,247	$53,751							(b)	(b)					118	472	10,148	61,789
Florida							(b)	(b)									(b)	(b)
Georgia			67,752	$292,943					12,033	7,577	1,325	1,325			85,140	17,620	166,250	319,465
Idaho									(b)	(b)							(b)	(b)
Illinois									93,888	120,008	32,295	26,165	(b)	(b)	37,421	22,847	163,904	169,320
Indiana									45,766	36,969	4,056	3,298	(b)	(b)	2,030	4,600	52,015	45,030
Iowa									119	244					11,460	5,229	11,579	5,473
Kentucky							13,677	$45,199	62,998	72,479	(b)	(b)	(b)	(b)	596	691	80,684	121,676
Louisiana															(b)	(b)	(b)	(b)
Maryland									15,976	31,453	(b)	(b)	(b)	(b)	500	500	17,157	32,966
Massachusetts									(b)	(b)			459	593			699	1,313
Michigan					1,198	$3,805							(b)	(b)			3,142	5,605
Minnesota															(b)	(b)	(b)	(b)
Mississippi											(b)	(b)					(b)	(b)
Missouri	(b)	(b)							303,432	604,777	(b)	(b)			(b)	(b)	308,385	641,040
Montana									(b)	(b)			(b)	(b)			3,670	17,842
Nebraska									(b)	(b)	(b)	(b)			(b)	(b)	(b)	(b)
New Jersey					(b)	(b)	8,639	27,879	227,813	412,353	12,871	28,706	19,886	35,808	71,784	113,132	340,726	617,904
New Mexico									2,507	7,077					61	243	2,568	7,320
New York					(b)	(b)			(b)	(b)			(b)	(b)	1,520	1,170	7,261	15,913
North Carolina	15,699	143,505									165	83			205	108	16,069	143,696
North Dakota									(b)	(b)							(b)	(b)
Ohio					(b)	(b)			187,096	184,325	65,249	47,936	(b)	(b)	30,370	12,262	285,590	247,413
Oregon									(b)	(b)	(b)	(b)					(b)	(b)
Pennsylvania			20,593	128,291					377,090	567,913	(b)	(b)	7,627	7,717	33,507	27,309	441,918	735,321
South Carolina			24,688	118,388					(b)	(b)							24,854	119,218
Tennessee							27,257	78,497	32,628	44,500	(b)	(b)					59,975	123,132
Texas									2,459	9,663	(b)	(b)			31	153	3,204	10,610
Utah	(b)	(b)							5,273	8,538							5,398	8,807
Vermont	5,114	$6,670							(b)	(b)					206	206	5,388	37,081
Virginia	(b)	(b)							(b)	(b)			(b)	(b)	3,240	324	4,958	4,333

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Washington			(c)	(c)	(b)	(b)			502	3,364					(b)	(b)	829	4,340
West Virginia									85,103	59,610							85,103	59,610
Wisconsin									(b)	(b)			(b)	(b)	(b)	(b)	310	413
Wyoming									(b)	(b)					(b)	(b)	(b)	(b)
Undistributed[d]	971	7,594			6,448	14,969	26,045	150,335	11,450	45,631	9,436	10,441	6,087	6,040	38,974	65,284	[e] 63,589	[e] 193,769
	28,031	241,520	113,033	539,622	7,646	18,774	75,348	301,910	1,570,481	2,361,482	13,4297	126,429	101,968	98,863	332,150	288,341	2,362,954	3,971,941
Average price per ton		8.62		4.77		2.46		4.01		1.50		.94		.92		.87		1.68

[a] Including bentonite, modeling clay, sewer-pipe clay, terra-cotta clay, and clay for medicinal use.
[b] Included in "Undistributed."
[c] Paper clay, for Washington, is included in "Washington miscellaneous."
[d] Includes all clay reported by less than 3 producers in 1 State.
[e] Made up of State totals of Arkansas, Connecticut, Florida, Idaho, Louisiana, Minnesota, Mississippi, Nebraska, North Dakota, Oregon, and Wyoming.

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Clay marketed in the United States in 1916.

State.	Kaolin.		Paper clay.		Slip clay.		Ball clay.		Fire clay.		Stoneware clay.		Brick clay.		Miscellaneous clay.[a]		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	.....	.....	.....	.....	.....	.....	.....	.....	40,235	$50,618	.....	.....	.....	.....	1,244	$435	41,479	$51,053
Arkansas	.....	.....	.....	.....	.....	.....	.....	.....	(b)	(b)	.....	.....	.....	.....	.....	.....	(b)	(b)
California	366	$4,103	(c)	(c)	(b)	(b)	(b)	(b)	80,218	96,598	(b)	(b)	(b)	(b)	c17,123	c16,415	106,330	133,950
Colorado	.....	.....	.....	.....	.....	.....	.....	.....	31,738	48,150	.....	.....	45,198	$29,480	50	200	76,986	77,830
Connecticut	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(b)	(b)	.....	.....	(b)	(b)
Delaware	8,888	85,560	.....	.....	.....	.....	.....	.....	(b)	(b)	.....	.....	.....	.....	.....	.....	12,844	101,384
Florida	.....	.....	.....	.....	.....	.....	(b)	(b)	.....	.....	.....	.....	.....	.....	.....	.....	(b)	(b)
Georgia	.....	.....	92,671	$417,394	.....	.....	.....	.....	10,370	6,703	(b)	(b)	.....	.....	90,150	18,300	193,791	443,147
Idaho	.....	.....	.....	.....	.....	.....	.....	.....	(b)	(b)	.....	.....	.....	.....	.....	.....	(b)	(b)
Illinois	.....	.....	.....	.....	.....	.....	.....	.....	131,058	327,666	25,615	$24,970	.....	.....	40,428	25,804	197,701	378,440
Indiana	(b)	(b)	.....	.....	(b)	(b)	.....	.....	56,534	50,564	(b)	(b)	(b)	(b)	3,778	6,304	69,748	65,537
Iowa	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	21,829	2,427	21,829	2,427
Kentucky	.....	.....	.....	.....	.....	.....	15,282	$50,831	44,070	116,287	(b)	(b)	(b)	(b)	10	200	62,247	170,984
Maryland	(b)	(b)	.....	.....	.....	.....	.....	.....	28,753	59,831	.....	.....	(b)	(b)	1,462	1,950	45,975	82,667
Massachusetts	.....	.....	.....	.....	.....	.....	.....	.....	(b)	(b)	.....	.....	(b)	(b)	.....	.....	892	1,296
Michigan	.....	.....	.....	.....	2,810	$10,509	.....	.....	.....	.....	.....	.....	(b)	(b)	.....	.....	3,454	11,153
Minnesota	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(b)	(b)	(b)	(b)
Mississippi	.....	.....	.....	.....	.....	.....	.....	.....	(b)	(b)	.....	.....	.....	.....	.....	.....	(b)	(b)
Missouri	(b)	(b)	.....	.....	.....	.....	.....	.....	435,620	940,309	(b)	(b)	(b)	(b)	(b)	(b)	439,583	988,884
Montana	.....	.....	.....	.....	.....	.....	.....	.....	(b)	(b)	.....	.....	.....	.....	.....	.....	(b)	(b)
Nebraska	.....	.....	.....	.....	.....	.....	.....	.....	(b)	(b)	(b)	(b)	.....	.....	(b)	(b)	(b)	(b)
New Jersey	.....	.....	.....	.....	.....	.....	6,218	26,397	264,033	585,230	8,288	22,388	22,074	17,880	71,203	135,901	371,916	790,796
New Mexico	.....	.....	.....	.....	.....	.....	.....	.....	3,602	9,511	.....	.....	.....	.....	.....	.....	3,602	9,511
New York	.....	.....	.....	.....	(b)	(b)	.....	.....	(b)	(b)	.....	.....	(b)	(b)	1,826	1,341	11,158	36,413
North Carolina	(b)	(b)	.....	.....	.....	.....	.....	.....	.....	.....	70	35	(b)	(b)	.....	.....	17,562	151,823
North Dakota	.....	.....	.....	.....	.....	.....	.....	.....	(b)	(b)	.....	.....	.....	.....	.....	.....	(b)	(b)
Ohio	.....	.....	.....	.....	(b)	(b)	.....	.....	232,522	252,273	65,107	42,246	(b)	(b)	22,619	9,667	324,722	309,369
Oregon	.....	.....	.....	.....	.....	.....	.....	.....	(b)	(b)	(b)	(b)	.....	.....	.....	.....	(b)	(b)
Pennsylvania	.....	.....	28,207	183,397	.....	.....	.....	.....	512,304	800,917	(b)	(b)	8,584	5,534	25,178	14,739	577,147	1,098,129
South Carolina	.....	.....	32,556	168,120	.....	.....	.....	.....	(b)	(b)	.....	.....	.....	.....	.....	.....	32,881	170,070
Tennessee	.....	.....	.....	.....	.....	.....	33,230	110,756	42,634	63,696	22,306	33,497	(b)	(b)	.....	.....	101,617	209,951
Texas	.....	.....	.....	.....	.....	.....	.....	.....	2,156	9,498	(b)	(b)	(b)	(b)	53	116	2,936	d10,531
Utah	.....	.....	.....	.....	.....	.....	.....	.....	(b)	(b)	.....	.....	.....	.....	.....	.....	(b)	(b)
Vermont	(b)	(b)	.....	.....	.....	.....	.....	.....	(b)	(b)	.....	.....	.....	.....	(b)	(b)	5,397	40,684
Virginia	(b)	(b)	.....	.....	.....	.....	.....	.....	(b)	(b)	.....	.....	.....	.....	(b)	(b)	(b)	(b)
Washington	.....	.....	.....	.....	(b)	(b)	.....	.....	630	3,934	(b)	(b)	.....	.....	.....	.....	1,840	6,251
West Virginia	.....	.....	.....	.....	.....	.....	.....	.....	121,931	125,363	.....	.....	(b)	(b)	.....	.....	122,944	126,283

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Wisconsin									(b)	(b)			(b)	(b)			(b)	(b)	(b)	(b)
Wyoming									(b)	(b)									(b)	(b)
Undistributed d	38,469	217,156			11,254	87,430	34,931	203,168	18,806	70,881	14,572	14,643	21,308	23,960	39,719	77,512	e 86,009	e 283,211		
Average price per ton	47,723	306,819 6.43	153,434	768,911 5.01	14,064	47,939 3.41	89,761	391,152 4.36	2,057,814	3,708,009 1.80	135,958	137,779 1.01	97,164	76,854 0.79	336,672	314,311 0.93	2,932,590	5,751,774 1.96		

a Including bentonite, modeling clay, sewer-pipe clay, terra-cotta clay, and clay for medicinal use.
b Included in "Undistributed."
c Paper clay for California is included in "California miscellaneous."
d Includes all clay reported by less than 3 producers in 1 State.
e Made up of State totals of Arkansas, Connecticut, Florida, Idaho, Minnesota, Mississippi, Montana, Nebraska, North Dakota, Oregon, Utah, Virginia, Wisconsin, and Wyoming.

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Thirty-nine States reported sales of clay in 1916, a decrease of one—Louisiana. The leading clay-producing State, as for many years, in both quantity marketed and value of output, was Pennsylvania. The quantity of clay sold as clay in this State in 1916 increased 135,229 tons and its value increased $362,808. Pennsylvania reported one-fifth of all clay marketed as such and nearly one-fifth of its value. Fire clay is the most important clay mined in the State and it constituted 89 per cent of the output and 81 per cent of the value of clay marketed there. Missouri which was third in output and second in value in 1915 ranked second in quantity and value in 1916, reporting 15 per cent of the total output and 17 per cent of the total value, an increase of 131,198 tons and of $347,844, compared with 1915. In this State practically all of the clay mined in 1916 was fire clay, 99 per cent being of that variety, and its value constituted 95 per cent of the total for the State. New Jersey was third in production in 1916, with an increase of 31,190 tons and of $172,892 in value, compared with 1915. Fire clay was the principal clay mined in this State and constituted 71 per cent of its output and 74 of its value in 1916. Ohio was fourth in quantity in 1916 and sixth in value, the increase being 39,132 tons and $61,956 in value, compared with 1915. Fire clay constituted 72 per cent of the quantity and 82 per cent of the value of clay marketed in Ohio in 1916. Illinois was fifth in output and value, and Georgia was sixth in output and fourth in value. These six States—Pennsylvania, Missouri, New Jersey, Ohio, Illinois, and Georgia—reported 2,104,860 tons, or 72 per cent of the total quantity, and $4,008,765, or 70 per cent, of the total value for clay in 1916.

Fire clay.—In 1916, as in 1915, Pennsylvania was the leading State in production, but second in value of fire clay, and reported 25 per cent of the output and 24 per cent of the total value, an increase of 135,214 tons and of $323,004, compared with 1915. Missouri was second in quantity and first in value, as in 1915, and reported 21 per cent of the quantity and 25 per cent of the value of fire clay in 1916, an increase of 132,188 tons and of $335,532. New Jersey was third in both quantity and value, reporting 13 per cent of the quantity and 16 per cent of the value, an increase of 36,220 tons and of $172,877. Ohio was fourth in output and fifth in value, and Illinois was fifth in output and fourth in value. The average price per ton of fire clay in these States in 1916 was: Illinois, $2.49; Missouri, $2.16; New Jersey, $2.22; Ohio, $1.08; and Pennsylvania, $1.74. In 1915 the corresponding prices were: Illinois, $1.28; Missouri, 1.99; New Jersey, $1.81; Ohio, $0.99; and Pennsylvania, $1.51.

Kaolin.—Kaolin, the purest form of clay and in some respects the most valuable, was reported from eight States, an increase of one. Indiana and Maryland, which reported none for 1915, entered list of producers in 1916, and Utah dropped out. North Carolina was the leading State, reporting nearly two-fifths of the output and nearly one-half of the value.

Paper clay.—Paper clay, the second kind in output, value, and average price, was reported from four States, the same number as for 1915, but Washington, which reported a small output in 1915, reported none in 1916, and California entered as a producer of paper clay. Georgia is the principal producer of this variety of clay and

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reported 60 per cent of the quantity and 54 per cent of the value, an increase of 24,919 tons and of $124,451.

Ball clay.—Florida and Tennessee are the largest producers of ball clay, these two States reporting about 75 per cent of the quantity and 80 per cent of the value for 1916.

IMPORTS.

Clay imported and entered for consumption in the United States, 1907–1916.

Year.	Kaolin or china clay.			Common blue and Gross-Almerode glass-pot clay.		All other clays.				Total.	
						Unwrought.		Wrought.			
	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1907..	239,923	$1,582,893	$6.60	12,378	$110,686	31,196	$145,698	2,520	$81,155	286,017	$1,920,432
1908..	176,895	1,129,847	6.39	4,872	37,053	27,730	129,411	1,372	22,990	219,869	1,319,301
1909..	246,381	1,565,779	6.11	12,346	104,401	30,147	134,978	1,906	50,632	290,780	1,795,790
1910..	257,902	1,593,472	6.18	21,176	181,334	27,890	113,352	1,496	26,205	308,464	1,914,363
1911..	255,107	1,461,068	5.73	17,193	124,278	26,086	100,540	1,032	10,436	299,418	1,696,322
1912..	278,276	1,629,105	5.85	23,112	184,018	32,473	127,004	794	12,109	334,655	1,952,236
1913..	268,666	1,623,993	6.04	24,986	204,911	42,582	155,693	1,889	22,178	338,123	2,006,775
1914..	328,038	1,927,425	5.88	16,761	122,325	50,069	195,956	3,232	41,712	398,100	2,287,418
1915..	209,132	1,152,778	5.51	8,864	62,569	23,718	90,367	1,343	12,433	243,057	1,318,147
1916..	253,707	1,326,684	5.22	2,501	12,134	42,478	163,421	180	1,994	298,866	1,504,233

The imports of clay are unimportant, except kaolin or china clay and the "common blue" and Gross-Almerode, which include high-grade fire clay imported principally from Germany. Communication with England, from which nearly all imported kaolin comes, being but little interrupted, the imports of that material have not suffered since the beginning of the war so greatly as those from Germany. In fact, the imports of kaolin in 1916 increased 44,575 tons, or 21 per cent, compared with 1915, and $173,906, or 15 per cent, in value. The imports of "common blue" clay decreased 6,363 tons, or 72 per cent, and $50,435, or 81 per cent, in value compared with 1915. Compared with 1913, the decrease in imports of this variety of clay was 90 per cent in quantity and 94 per cent in value. The total quantity of clay imported increased 55,809 tons, or 23 per cent, and $186,086, or 14 per cent, in value compared with 1915.

Kaolin is the most important of the clays imported, 85 per cent of the quantity of imports and 88 per cent of the value in 1916 being of this variety.

BUILDING OPERATIONS.

The following tables show the building operations of some of the leading cities of the country in 1916. Efforts were made to obtain detailed information from 153 cities. For 129 cities sufficient detail was received to include them in a table showing classes of buildings; for 17 cities only the totals for permits or buildings and cost of buildings could be obtained; and for 7 cities no satisfactory data were obtained.

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The first table makes a comparison between 1915 and 1916 in 58 cities (Greater New York being considered as one city). The figures show that on the whole the building industry was in more prosperous condition than in 1915, though six cities that showed increase in 1915 showed decrease in 1916. The most noteworthy features of the building industry in 1916 were the large increase in the cost of building operations in the Borough of Manhattan ($60,405,370) and other large cities and the general increase in the average cost per permit or building.

Various causes are assigned for these changes. In many cities the increase in the building operations is ascribed to the general prosperity. In the Borough of Manhattan, New York, the great increase is ascribed by the superintendent of buildings to the passage of an ordinance restricting the use, height, and area of buildings by zones. In anticipation of this ordinance many plans were filed to escape its provisions. Manhattan showed the largest increase, but the Bronx and Brooklyn showed decrease. No report was received from the Borough of Queens. Boston showed the second largest increase. Much of this large increase may be more apparent than real, as the method of recording building statistics in Boston was changed in 1916 and credit was given to that year for a large amount of building which might have been credited to 1915.

Forty-nine of the cities given in the first table showed increase, and nine showed decrease in the total cost of building operations. Twenty-five cities that showed decrease in 1915 rallied and showed increase in 1916, 24 showed increase in both years, and only 3 cities showed decrease in both years, the net increase being $196,127,904, or more than 28 per cent. The largest proportionate increase was in Chester, Pa.—304 per cent. The largest decrease was in Cincinnati—$2,600,519, or 19 per cent—though if the Bronx is considered as a separate city it showed the largest decrease—$10,926,066—and also the largest proportionate decrease, 37 per cent.

The cost of building operations in these cities in 1916 ranged from $3,086,871 in Houston to $199,232,176 in Greater New York, the average for these 58 cities being $15,281,633.

The total number of permits or buildings increased 37,163 in 1916. They ranged from 591 in Sioux City, Iowa, to 26,585 in Greater New York. The average cost per operation in these 58 cities was $3,421 in 1916 and $3,110 in 1915. In Greater New York the average cost was $7,494 in 1916 and $5,948 in 1915; in the Borough of the Bronx it was $4,997 in 1916 and $7,360 in 1915; in Brooklyn it was $2,563 and $3,142 in 1915; in Manhattan it was $30,143 and $19,773; and in the Borough of Richmond it was $2,281 in 1916 and $897 in 1915. In Chicago, the second city in the cost of building operations, the average cost was $10,979 in 1916 and $9,409 in 1915; in Detroit, the third city, it was $3,097 in 1916 and $3,595 in 1915; in Philadelphia, the fourth city, it was $3,598 in 1916 and $2,522 in 1915; and in Boston, the fifth city, it was $5,440 in 1916 and $4,601 in 1915.

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Building operations in the leading cities of the United States in 1915 and 1916.

City.	1915		1916		Increase or decrease in 1916.	
	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Cost.	Per cent.
Akron, Ohio	2,532	$6,030,950	4,658	$12,824,536	+ $6,793,586	+112.65
Atlanta, Ga	2,752	4,589,214	2,419	3,685,663	− 903,551	− 19.69
Baltimore, Md	1,957	9,541,891	10,682	10,647,893	+ 1,106,002	+ 11.59
Boston, Mass	6,328	29,113,692	9,045	49,201,122	+ 20,087,430	+ 69.00
Bridgeport, Conn	1,635	8,790,274	2,091	7,064,564	− 1,725,710	− 19.63
Buffalo, N. Y	4,809	11,798,000	4,749	13,737,000	+ 1,939,000	+ 16.43
Cambridge, Mass	627	3,384,290	667	4,033,115	+ 648,825	+ 19.17
Camden, N. J	1,346	2,334,000	1,032	3,628,760	+ 1,294,760	+ 55.47
Canton, Ohio	727	2,005,190	1,348	3,869,655	+ 1,864,465	+ 92.98
Chester, Pa	295	772,225	656	3,122,750	+ 2,350,525	+304.38
Chicago, Ill	10,340	97,291,400	10,277	112,835,150	+ 15,543,750	+ 15.98
Cincinnati, Ohio	4,797	13,443,414	15,987	10,842,895	− 2,600,519	− 19.34
Cleveland, Ohio	14,451	32,660,305	14,022	33,108,260	+ 447,955	+ 1.37
Columbus, Ohio	2,836	4,928,425	3,141	7,194,240	+ 2,265,815	+ 45.97
Dallas, Tex	(a)	3,422,512	1,523	4,293,464	+ 870,952	+ 25.45
Denver, Colo	3,085	2,648,575	2,578	4,014,590	+ 1,366,015	+ 51.58
Des Moines, Iowa	771	1,967,817	855	3,375,945	+ 1,408,128	+ 71.56
Detroit, Mich	8,966	32,235,540	16,489	51,068,310	+ 18,832,770	+ 58.42
Duluth, Minn	1,816	2,714,464	1,963	10,223,598	+ 7,509,134	+276.68
El Paso, Tex	1,540	3,612,418	1,654	3,551,909	− 60,509	− 1.68
Flint, Mich	1,743	2,104,879	3,002	4,733,447	+ 2,628,568	+124.88
Fort Wayne, Ind	702	2,009,415	823	3,479,531	+ 1,470,116	+ 73.16
Grand Rapids, Mich	1,909	2,684,037	1,748	3,519,245	+ 835,208	+ 31.12
Hartford, Conn	1,403	5,575,895	1,423	7,383,163	+ 1,807,268	+ 32.41
Houston, Tex	4,314	2,425,555	3,449	3,086,871	+ 661,316	+ 27.26
Indianapolis, Ind	6,177	7,083,642	5,746	8,934,694	+ 1,851,052	+ 26.13
Jersey City, N. J	1,306	5,351,630	1,036	5,005,243	− 346,387	− 6.47
Kansas City, Mo	3,517	10,667,405	3,620	11,563,444	+ 896,039	+ 8.40
Los Angeles, Cal	7,845	11,888,662	7,565	15,036,045	+ 3,147,383	+ 26.47
Louisville, Ky	2,432	4,055,390	2,299	3,853,140	− 202,250	− 4.99
Memphis, Tenn	2,303	2,730,488	2,439	3,091,970	+ 361,482	+ 13.24
Milwaukee, Wis	3,882	11,564,325	4,008	13,010,312	+ 1,445,987	+ 12.50
Minneapolis, Minn	6,831	16,349,940	6,970	22,917,290	+ 6,567,350	+ 40.17
Newark, N. J	2,547	7,912,184	3,627	10,236,316	+ 2,324,132	+ 29.37
New Bedford, Mass	1,012	3,126,734	949	4,762,081	+ 1,635,347	+ 52.30
New Haven, Conn	1,524	7,104,947	1,465	5,022,556	− 2,082,391	− 29.31
New Orleans, La	1,334	2,950,357	1,015	3,117,604	+ 167,247	+ 5.67
Newton, Mass	843	3,073,079	989	3,166,948	+ 93,869	+ 3.05
New York, N. Y.:						
Bronx	3,988	29,351,126	3,687	18,425,060	− 10,926,066	− 37.23
Brooklyn	14,515	45,601,851	16,448	42,163,505	− 3,438,346	− 7.54
Manhattan	3,726	73,672,674	4,448	134,078,044	+ 60,405,370	+ 81.99
Richmond	3,250	2,916,413	2,002	4,565,567	+ 1,649,154	+ 56.55
	25,479	151,542,064	26,585	199,232,176	+ 47,690,112	+ 31.47
Oakland, Cal	3,352	5,045,290	3,683	5,368,290	+ 323,000	+ 6.40
Omaha, Nebr	1,351	5,385,005	1,454	7,226,107	+ 1,841,102	+ 34.19
Peoria, Ill	640	4,090,645	797	4,643,182	+ 552,537	+ 13.51
Philadelphia, Pa	13,884	35,010,640	13,708	49,319,225	+ 14,308,585	+ 40.87
Pittsburgh, Pa	3,916	14,227,020	4,175	13,554,810	− 672,210	− 4.72
Portland, Oreg	4,623	4,895,345	4,351	6,272,865	+ 1,377,520	+ 28.14
Providence, R. I	3,848	7,023,700	3,661	9,248,900	+ 2,225,200	+ 31.68
Richmond, Va	1,710	3,244,752	2,155	4,927,396	+ 1,682,644	+ 51.86
Rochester, N. Y	3,391	9,108,333	3,136	9,379,447	+ 271,114	+ 2.98
St. Louis, Mo	9,052	11,439,320	8,550	15,444,103	+ 4,004,783	+ 35.01
St. Paul, Minn	2,688	9,237,458	1,845	8,811,961	− 425,497	− 4.61
San Francisco, Cal	6,461	13,990,704	6,492	18,837,173	+ 4,846,469	+ 34.64
Seattle, Wash	8,217	6,456,995	8,486	8,304,689	+ 1,847,694	+ 28.62
Sioux City, Iowa	538	2,050,417	591	3,090,305	+ 1,039,888	+ 50.72
Springfield, Mass	1,495	6,066,394	1,695	7,101,032	+ 1,034,638	+ 17.06
Washington, D. C	4,428	9,749,301	5,239	17,494,804	+ 7,745,503	+ 79.45
Waterbury, Conn	748	2,600,350	1,337	4,270,000	+ 1,669,650	+ 64.21
Worcester, Mass	1,794	4,526,382	1,816	6,164,871	+ 1,638,489	+ 36.20
Youngstown, Ohio	1,108	2,573,555	1,355	3,400,079	+ 826,524	+ 32.12
	221,957	690,206,830	259,120	886,334,734	+196,127,904	+ 28.42

a Number of permits for Dallas not given.

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Building statistics of the leading cities of the United States in 1916.

City.	Wooden buildings.								Fire-resisting buildings.	
									Brick or hollow tile.	
	New.		Additions, alterations, and repairs.		Miscellaneous.		Total.		New.	
	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.
Akron, Ohio	3,429	$6,198,575	645	$283,235	.....	.....	4,074	$6,481,810	475	$5,697,151
Allentown, Pa	61	18,740	22	10,770	3	$1,100	86	30,610	617	1,843,315
Altoona, Pa	199	322,589	323	88,194	51	3,788	573	414,571	38	249,342
Atlanta, Ga	668	1,307,547	768	179,890	338	89,945	1,774	1,577,382	62	1,085,610
Atlantic City, N. J	101	239,571	784	336,905	51	13,115	936	589,591	127	949,287
Augusta, Ga	305	578,701	1,442	327,648	.....	.....	1,747	906,349	68	657,565
Baltimore, Md	56	229,450	.....	.....	.....	.....	56	229,450	2,506	6,700,137
Bayonne, N. J	145	536,799	187	96,603	56	26,188	388	659,590	38	447,568
Berkeley, Cal	394	1,175,653	771	272,650	.....	.....	1,165	1,448,303	15	236,300
Binghamton, N. Y	1,009	833,220	2,015	404,537	.....	.....	3,024	1,237,757	[b] 133	[b] 690,192
Birmingham, Ala	655	811,660	4,376	449,432	.....	.....	5,031	1,261,092	55	385,165
Boston, Mass	2,152	8,996,533	2,704	1,016,392	.....	.....	4,856	10,012,925	651	13,963,912
Bridgeport, Conn	500	2,145,000	350	1,225,165	195	162,117	1,045	3,532,282	350	2,028,032
Brockton, Mass	358	854,930	206	158,460	.....	.....	564	1,013,390	16	223,700
Buffalo, N. Y	3,011	5,423,000	1,304	677,000	.....	.....	4,315	6,100,000	366	5,358,000
Butte, Mont	426	800,404	278	108,291	.....	.....	704	908,695	131	515,950
Cambridge, Mass	189	926,220	261	151,075	.....	.....	450	1,077,295	71	1,876,750
Camden, N. J	63	94,800	145	73,700	109	44,810	317	213,310	546	1,822,400
Canton, Ohio	1,016	1,970,550	122	66,985	47	47,370	1,185	2,084,905	135	1,381,785
Charleston, S. C	105	287,936	281	73,978	.....	.....	386	361,914	11	89,600
Chattanooga, Tenn	105	203,600	[a] 2,242	[a] 235,860	.....	.....	2,347	439,460	87	418,450
Chester, Pa	.....	.....	.....	.....	69	20,300	69	20,300	519	1,690,900
Cincinnati, Ohio	1,591	1,997,800	[d] 4,351	[d] 1,634,275	8,933	611,355	[d] 14,895	[d] 4,243,430	[b] 1,092	[b] 6,599,465
Cleveland, Ohio	4,119	12,159,150	[d] 9,067	[d] 5,375,455	.....	.....	[d] 13,186	[d] 17,534,605	836	15,578,655
Columbus, Ohio	1,584	2,347,385	503	163,015	.....	.....	2,087	2,510,400	530	2,903,235
Covington, Ky	111	120,390	73	25,445	104	10,344	288	156,179	108	587,730
Denver, Colo	3	4,000	.....	.....	20	10,150	23	14,150	912	3,263,540
Des Moines, Iowa	603	1,223,992	41	29,969	.....	.....	734	1,253,961	96	729,597
Detroit, Mich	11,836	27,942,780	2,761	1,327,345	.....	.....	14,597	29,270,125	1,036	11,754,580
Dubuque, Iowa	107	317,649	16	13,210	.....	.....	123	330,859	18	224,974
Duluth, Minn	900	1,360,518	899	251,893	.....	.....	1,799	1,612,411	68	886,025

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East St. Louis, Ill	69	119,905	72	42,542	102	14,610	243	177,057	166	618,039
Elizabeth, N. J	338	971,848	71	80,005	.....	.....	409	1,051,853	47	783,228
Elmira, N. Y	157	368,800	.....	.....	.....	.....	157	368,800	24	1,130,850
Erie, Pa	842	1,618,374	[d] 568	[d] 544,413	.....	.....	[d] 1,410	[d] 2,162,787	[b] 125	[b] 637,405
Evansville, Ind	(f)	497,409	(f)	107,218	(f)	11,001	(f)	615,628	(f)	404,675
Fall River, Mass	315	1,076,665	222	298,127	.....	.....	537	1,374,792	27	[g] 698,000
Fitchburg, Mass	107	185,137	77	59,168	2	3,450	186	247,755	4	8,188
Flint, Mich	2,365	2,715,327	455	162,553	.....	.....	2,820	2,877,880	142	978,175
Fort Wayne, Ind	501	1,364,811	181	131,420	.....	.....	682	1,496,231	88	971,975
Fort Worth, Tex	310	389,743	326	129,685	10	8,206	646	507,634	62	750,707
Galveston, Tex	175	210,562	1,494	139,676	29	2,083	1,698	352,321	18	162,850
Grand Rapids, Mich	961	1,112,806	581	200,159	.....	.....	1,542	1,312,965	91	1,067,317
Harrisburg, Pa	43	18,780	38	18,448	.....	.....	81	37,228	352	1,474,500
Hartford, Conn	784	2,187,679	287	141,459	.....	.....	1,071	2,329,138	196	4,676,525
Haverhill, Mass	323	854,150	35	77,450	.....	.....	358	931,600	17	183,100
Hoboken, N. J	20	22,875	82	45,763	3	12,000	105	80,638	19	287,900
Holyoke, Mass	48	206,750	33	13,970	.....	.....	81	220,720	62	958,450
Houston, Tex	795	1,342,303	2,092	315,064	79	42,485	2,966	1,699,852	41	346,957
Indianapolis, Ind	1,387	4,482,723	2,775	1,069,846	894	344,553	5,056	5,897,122	60	738,725
Jacksonville, Fla	200	392,375	236	98,410	32	91,348	468	582,133	44	559,432
Kalamazoo, Mich	87	198,650	43	39,420	13	7,525	143	245,595	39	278,600
Kansas City, Kans	267	386,560	324	136,576	.....	.....	591	523,136	21	225,294
Kansas City, Mo	1,338	3,459,255	626	361,955	556	183,299	2,520	4,004,509	331	4,582,175
Knoxville, Tenn	60	128,654	571	76,605	.....	.....	631	205,259	34	196,789
Lancaster, Pa	.....	.....	.....	.....	1	1,000	1	1,000	206	770,642
Lawrence, Mass	163	703,540	91	105,133	.....	.....	254	808,673	24	620,800
Lincoln, Nebr	343	806,248	82	61,460	.....	.....	425	867,708	60	417,640
Little Rock, Ark	221	437,771	237	85,673	.....	.....	458	523,444	8	586,500
Los Angeles, Cal	4,052	7,321,515	1,906	943,421	.....	.....	5,958	8,264,936	247	3,516,296
Louisville, Ky	585	1,292,320	803	159,130	358	64,820	1,746	1,516,270	68	516,550
Lowell, Mass	335	655,934	386	180,919	.....	.....	721	836,853	41	294,720
Lynn, Mass	291	535,835	252	123,097	.....	.....	543	658,932	21	388,900
McKeesport, Pa	108	156,739	60	34,272	.....	.....	168	191,011	64	515,035
Macon, Ga	114	120,594	386	67,193	15	28,516	515	216,303	116	344,273
Malden, Mass	113	317,000	155	80,400	.....	.....	268	397,400	14	272,000
Manchester, N. H	409	734,489	618	233,485	.....	.....	1,027	967,974	26	400,995
Milwaukee, Wis	1,729	3,717,094	1,576	1,338,635	130	54,170	3,435	5,109,899	.....	.....
Minneapolis, Minn	4,031	7,698,283	2,006	1,036,790	.....	.....	6,037	8,735,075	295	4,973,930
Mobile, Ala	43	25,995	20	5,825	.....	.....	63	31,820	6	28,170
Montgomery, Ala	112	169,845	1,264	116,356	.....	.....	1,376	286,201	15	104,750
Nashville, Tenn	213	222,351	1,073	100,081	3,967	96,597	5,253	419,029	270	2,949,427
Newark, N. J	1,381	1,707,066	763	1,435,745	386	86,760	2,530	3,229,571	865	5,910,180
New Bedford, Mass	356	1,391,350	227	176,315	128	78,465	711	1,646,130	228	2,660,951
New Britain, Conn	220	733,435	110	89,510	.....	.....	330	822,945	280	596,065
New Haven, Conn	755	1,882,830	.....	.....	407	249,000	1,162	2,131,830	167	2,647,226
New York, N. Y.:										
Borough of Bronx	72	274,500	267	248,470	12	5,975	351	528,945	566	16,445,107
Borough of Brooklyn	1,420	4,125,055	1,379	790,260	.....	.....	2,799	4,915,315	3,526	31,272,425
Borough of Manhattan	10	60,600	29	35,000	.....	.....	39	95,600	254	13,053,550
Borough of Richmond	713	1,107,659	435	155,763	.....	.....	1,148	1,263,422	665	3,140,475
Norfolk, Va	212	435,922	84	35,297	53	36,305	349	507,524	130	769,266

For footnotes see p. 582.

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Building statistics of the leading cities of the United States in 1916—Continued.

City.	Wooden buildings.								Fire-resisting buildings.	
									Brick or hollow tile.	
	New.		Additions, alterations, and repairs.		Miscellaneous.		Total.		New.	
	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.
Oakland, Cal.	2,356	3,258,664	1,240	395,871	.....	.....	3,596	3,654,535	54	992,879
Omaha, Nebr.	826	2,041,897	212	94,764	172	28,035	1,210	2,164,696	126	2,260,063
Passaic, N. J.	97	132,615	93	43,620	.....	.....	190	176,235	92	1,095,383
Paterson, N. J.	278	685,331	554	106,102	.....	.....	832	791,433	127	1,016,906
Pawtucket, R. I.	152	521,925	115	54,315	115	42,653	382	618,893	30	594,200
Philadelphia, Pa.	28	76,525	23	38,210	.....	.....	51	114,735	9,216	[a] 32,587,025
Portland, Maine	299	665,735	191	186,452	.....	.....	490	852,187	34	692,390
Portland, Oreg.	1,698	2,118,925	1,849	495,285	10	103,235	3,557	2,717,445	65	975,600
Providence, R. I.	922	1,991,500	2,293	554,400	.....	.....	3,215	2,545,900	[b] 187	[b] 5,062,100
Pueblo, Colo.	2	1,300	37	16,960	21	2,066	60	20,326	112	240,535
Quincy, Ill.	53	118,820	6	2,400	.....	.....	59	121,220	30	183,220
Reading, Pa.	.....	.....	657	14,225	.....	.....	657	14,225	361	1,089,800
Richmond, Va.	327	863,415	386	106,548	92	48,108	805	1,018,071	805	2,575,184
Rochester, N. Y.	1,718	4,504,458	817	488,773	.....	.....	2,535	4,993,231	166	2,521,730
Sacramento, Cal.	128	369,702	764	235,646	.....	.....	892	605,348	36	859,346
Saginaw, Mich.	169	297,480	69	38,510	.....	.....	238	335,990	11	64,900
St. Joseph, Mo.	280	183,670	[c] 234	[c] 258,938	.....	.....	514	442,608	48	625,635
St. Louis, Mo.	89	103,995	675	93,290	10	13,725	774	211,000	1,650	9,175,422
St. Paul, Minn.	1,149	3,479,898	421	233,669	.....	.....	1,570	3,713,567	124	1,811,046
Salem, Mass.	173	540,265	213	157,559	.....	.....	386	697,824	66	812,425
Salt Lake City, Utah.	137	107,843	85	55,134	.....	.....	222	162,977	718	2,436,020
San Antonio, Tex.	902	736,253	621	122,601	22	10,270	1,545	869,124	46	197,730
San Diego, Cal.	598	761,376	[c] 759	[c] 334,527	.....	.....	1,357	1,095,903	61	285,331
San Francisco, Cal.	1,787	6,561,000	3,800	919,843	.....	.....	5,587	7,480,843	112	2,870,290
Savannah, Ga.	375	511,950	113	36,150	.....	.....	488	548,100	22	401,460
Schenectady, N. Y.	414	739,407	428	110,958	.....	.....	842	850,365	39	78,000
Scranton, Pa.	185	467,117	201	116,801	170	224,030	556	807,948	20	312,400
Seattle, Wash.	3,529	3,050,324	3,456	685,879	384	47,300	7,369	3,783,503	27	729,880
Sioux City, Iowa.	422	1,034,135	40	46,150	.....	.....	462	1,080,285	83	841,770
Somerville, Mass.	131	[d]	100	[d]	.....	.....	231	[e] 686,300	24	189,946
Spokane, Wash.	175	365,570	444	135,995	473	41,976	1,092	543,541	35	622,415
Springfield, Ill.	321	730,375	207	97,220	.....	.....	528	827,595	62	1,144,800

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Springfield, Mass.	828	2,153,185	384	158,046	9	6,825	1,221	2,318,056	285	4,096,970
Superior, Wis.	294	242,866	363	524,178	.....	.....	657	767,044	20	562,190
Syracuse, N. Y.	634	1,528,590	1,021	785,258	.....	.....	1,655	2,313,848	.....	.....
Tacoma, Wash.	287	590,599	547	174,939	314	62,319	1,148	827,857	29	318,700
Tampa, Fla.	355	402,097	600	131,193	.....	.....	1,045	533,290	24	636,190
Terre Haute, Ind.	290	315,442	222	74,425	.....	.....	512	389,867	29	333,103
Toledo, Ohio.	2,782	5,452,437	917	588,028	274	90,973	3,973	6,131,438	226	3,305,489
Topeka, Kans.	(l)	(l)	(l)	(l)	(l)	(l)	[k] 456	[k] 503,365	.....	.....
Troy, N. Y.	45	177,450	242	76,265	.....	.....	287	253,715	20	465,850
Utica, N. Y.	361	905,665	99	82,635	.....	.....	460	988,300	73	663,075
Washington, D. C.	395	1,004,449	429	77,615	345	19,729	1,169	1,101,793	1,453	14,458,326
West Hoboken, N. J.	16	10,293	70	48,551	.....	.....	86	58,844	31	263,750
Wheeling, W. Va.	33	44,375	293	54,507	.....	.....	326	98,882	40	713,794
Wichita, Kans.	225	607,490	27	23,400	.....	.....	252	630,890	53	633,300
Wilkes-Barre, Pa.	177	337,074	221	66,059	266	39,642	664	442,775	116	507,517
Woonsocket, R. I.	217	502,675	79	51,975	.....	.....	296	554,650	9	70,352
Worcester, Mass.	915	2,434,553	.....	.....	.....	.....	915	2,434,553	157	1,757,410
Yonkers, N. Y.	190	583,200	59	45,400	.....	.....	249	628,600	105	1,305,700
York, Pa.	129	56,042	203	22,245	.....	.....	332	78,287	73	356,730
	93,277	196,725,197	89,304	36,247,043	19,850	3,243,636	[l] 202,887	[m] 237,406,041	39,207	312,545,908
Percentage of total	.....	23.07	.....	4.25	.....	.38	.....	27.84	.....	36.65

For footnotes see p. 582.

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Building statistics of the leading cities of the United States in 1916—Continued.

City.	Fire-resisting buildings.											
	Brick or hollow tile.		Stone.				Concrete.				Steel skeleton.	
	Additions, alterations and repairs.		New.		Additions, alterations and repairs.		New.		Additions, alterations and repairs.		New.	
	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.
Akron, Ohio	109	645,575										
Allentown, Pa	96	151,390					9	21,335	3	2,825		
Altoona, Pa	35	71,845							1	3,500		
Atlanta, Ga	575	539,671					8	483,000				
Atlantic City, N. J	94	202,039					6	44,635	2	250		
Augusta, Ga	113	171,181	1	10,000			2	71,000				
Baltimore, Md	8,102	3,183,656										
Bayonne, N. J	18	89,604					4	179,998	3	8,520		
Berkeley, Cal	6	20,000					4	146,600			2	870,000
Binghamton, N. Y												
Birmingham, Ala	340	282,222					7	447,620	2	10,500		
Boston, Mass	1,771	4,240,892	10	432,660	90	327,759	125	4,233,750	27	200,135	153	1,842,396
Bridgeport, Conn	172	250,050					524	1,254,200				
Brockton, Mass	6	15,350										
Buffalo, N. Y	41	272,000	3	400,000			9	981,000			15	626,000
Butte, Mont	177	86,764					44	450,710				
Cambridge, Mass	55	151,555					44	883,415	9	13,175		
Camden, N. J	114	79,050	1	7,000			30	1,384,050				
Canton, Ohio	19	63,875	2	160,000			7	179,090				
Charleston, S. C	67	93,147										
Chattanooga, Tenn	(a)	(a)					5	616,850				
Chester, Pa	17	32,800	8	122,000							11	1,245,900
Cincinnati, Ohio												
Cleveland, Ohio												
Columbus, Ohio	394	586,735	2	425	1	4,000	35	344,050	11	88,075	5	723,000
Covington, Ky	54	90,055										
Denver, Colo	c 1,210	c 602,010										
Des Moines, Iowa	14	87,937					6	950,500			5	353,960
Detroit, Mich	546	2,068,025					174,	4,933,820	49	671,235	52	1,782,600
Dubuque, Iowa	12	52,500					16	56,775				

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Duluth, Minn.	91	244,162										
East St. Louis, Ill.	1	400										
Elizabeth, N. J.	12	25,700					14	101,273			13	339,579
Elmira, N. Y.							41	205,250				
Erie, Pa.												
Evansville, Ind.	(f)	257,817										
Fall River, Mass.	18	(g)	2	20,000			12	g 191,950	2	(g)		
Fitchburg, Mass.	11	54,535	2	350	1	300	16	19,125	4	8,100		
Flint, Mich.	33	167,192					5	650,000			2	60,200
Fort Wayne, Ind.	41	96,300					12	915,025				
Fort Worth, Tex.	122	165,450					12	701,393	3	2,700		
Galveston, Tex.	192	109,822			1	30	5	75,272	2	25,060		
Grand Rapids, Mich.	69	369,572					37	330,595	1	800	8	437,996
Harrisburg, Pa.	75	187,520										
Hartford, Conn.	156	377,500										
Haverhill, Mass.	8	26,400					19	20,450				
Hoboken, N. J.	90	65,997					5	701,500	1	50,000		
Holyoke, Mass.	25	145,400					2	13,000				
Houston, Tex.	368	155,775			1	10	15	544,646	48	56,672		
Indianapolis, Ind.	534	267,461					50	43,460			46	1,987,926
Jacksonville, Fla.	105	417,359										
Kalamazoo, Mich.							1	37,000			1	20,000
Kansas City, Kans.												
Kansas City, Mo.	333	634,200	6	81,000			25	1,954,000			1	50,000
Knoxville, Tenn.	67	66,723										
Lancaster, Pa.	113	138,035	1	45,000			1	6,000			1	63,000
Lawrence, Mass.	26	53,600					20	25,850	11	7,800		
Lincoln, Nebr.	10	32,450	1	80,000	1	200	22	541,504				
Little Rock, Ark.	116	23,948										
Los Angeles, Cal.	1,340	951,988					16	1,440,825			4	862,000
Louisville, Ky.	368	374,580										
Lowell, Mass.	64	170,795	1	39,000	3	1,605					1	150,000
Lynn, Mass.	32	144,140					12	61,430	1	5,000	9	146,925
McKeesport, Pa.												
Macon, Ga.							2	110,000				
Malden, Mass.	33	55,000	25	18,000			1	110,000				
Manchester, N. H.	51	78,780	1	200								
Milwaukee, Wis.			321	2,275,402							244	5,493,801
Minneapolis, Minn.	350	866,315	3	55,000	19	18,280	48	73,795	19	8,080	128	7,542,080
Mobile, Ala.	14	15,400										
Montgomery, Ala.	121	53,978										
Nashville, Tenn.	824	279,513										
Newark, N. J.							214	951,365			18	145,200
New Bedford, Mass.	9	55,000					1	400,000				
New Britain, Conn.												
New Haven, Conn.												
New York, N. Y.:												
Borough of Bronx	339	1,102,860										
Borough of Brooklyn	10,123	5,975,765										
Borough of Manhattan	3,117	9,422,389									300	101,575,995
Borough of Richmond	161	149,675										

For footnotes see p. 582.

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Building statistics of the leading cities of the United States in 1916—Continued.

City.	Fire-resisting buildings.											
	Brick or hollow tile.		Stone.				Concrete.				Steel skeleton.	
	Additions, alterations and repairs.		New.		Additions, alterations and repairs.		New.		Additions, alterations and repairs.		New.	
	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.
Norfolk, Va.	83	$161,297					5	$203,990	1	$1,000	1	$1,000,000
Oakland, Cal.	4	18,925					23	512,971			6	188,980
Omaha, Nebr.	50	218,421					30	2,548,500				
Passaic, N. J.	58	149,140										
Paterson, N. J.	99	144,602					65	366,519	4	965		
Pawtucket, R. I.	(g)	(g)										
Philadelphia, Pa.	4,284	6,510,995	22	$62,210	15	$28,245	42	7,044,515	28	1,118,700	8	1,780,500
Portland, Maine.	52	109,165										
Portland, Oreg.	613	338,450					12	492,300	99	79,070	5	1,670,000
Providence, R. I.	h 259	h 1,640,900										
Pueblo, Colo.	23	55,787	1	800			6	64,950				
Quincy, Ill.	12	25,150	1	6,000			1	3,500				
Reading, Pa.	688	219,100	15	60,400	17	13,475	61	69,675	24	21,175	237	181,850
Richmond, Va.	482	582,516			2	16,115	5	381,000	2	46,800	3	184,000
Rochester, N. Y.	211	496,438					125	265,474	62	88,335	7	1,012,706
Sacramento, Cal.	293	293,614					2	340,000	6	3,850		
Saginaw, Mich.					16	25,210						
St. Joseph, Mo.												
St. Louis, Mo.	2,405	2,242,724									105	3,356,600
St. Paul, Minn.	123	663,740									28	2,623,608
Salem, Mass.	18	43,875										
Salt Lake City, Utah.	206	270,752										
San Antonio, Tex.	13	51,744	3	10,200			42	1,085,033	8	24,700		
San Diego, Cal.							6	417,928			1	25,000
San Francisco, Cal.	390	600,000	28	4,406,716	16	292,130	101	2,987,204	258	200,000		
Savannah, Ga.	59	206,450							1	55,000	2	12,870
Schenectady, N. Y.	89	44,500			3	123,000	61	479,950	15	123,000		
Scranton, Pa.	68	416,092										
Seattle, Wash.	796	540,460					41	3,018,090	121	208,045		
Sioux City, Iowa.	35	86,250					11	1,082,000				

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Somerville, Mass.									122	74,306	6	159,300
Spokane, Wash.	158	382,261					13	38,570				
Springfield, Ill.	84	153,142										
Springfield, Mass.	189	684,006										
Superior, Wis.	16	71,695										
Syracuse, N. Y.							140	239,515				
Tacoma, Wash.	185	161,179					10	310,345				
Tampa, Fla.	131	119,183										
Terre Haute, Ind.	44	69,900					29	22,910				
Toledo, Ohio.	96	255,341										
Topeka, Kans.			25	130,000			3	175,000				
Troy, N. Y.	85	206,021					2	200,375				
Utica, N. Y.	26	64,500					17	84,600			1	35,000
Washington, D. C.	1,526	1,420,032					25	61,532				
West Hoboken, N. J.	22	137,924					1	2,000				
Wheeling, W. Va.	306	164,020										
Wichita, Kans.	15	23,700					22	560,925			1	150,000
Wilkes-Barre, Pa.	90	132,355	1	84,000	7	14,500			5	533		
Woonsocket, R. I.	5	12,335					12	75,590	1	1,500		
Worcester, Mass.	c 744	c 1,972,908										
Yonkers, N. Y.	50	180,900	17	72,500	5	4,000	7	13,600	2	800		
York, Pa.	258	187,388										
	49,162	60,429,301	503	8,578,863	198	868,859	2,587	51,035,867	958	3,205,206	1,430	138,608,962
Percentage of total		17.08		1.01		.10		5.98		.38		16.26

For footnotes see p. 582.

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Building statistics of the leading cities of the United States in 1916—Continued.

City.	Fire-resisting buildings.						Grand total.		Rank in cost of building operations.
	Steel skeleton. Additions, alterations, and repairs.		Miscellaneous.		Total.				
	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	
Akron, Ohio					584	$6,342,726	4,658	$12,824,536	15
Allentown, Pa			22	$129,110	747	2,147,975	833	2,178,585	74
Altoona, Pa					74	324,687	647	739,258	131
Atlanta, Ga					645	2,108,281	2,419	3,685,663	47
Atlantic City, N. J					229	1,196,211	1,165	1,785,802	88
Augusta, Ga					184	909,746	1,931	1,816,095	86
Baltimore, Md			18	534,650	10,626	10,418,443	10,682	10,647,893	18
Bayonne, N. J			8	3,985	71	724,675	459	1,384,265	109
Berkeley, Cal			4	85,000	31	1,357,900	1,196	2,806,203	62
Binghamton, N. Y					133	690,192	3,157	1,927,949	82
Birmingham, Ala					404	1,125,507	5,435	2,386,599	67
Boston, Mass	20	$51,425	[c] 1,342	[c] 13,895,268	4,189	39,188,197	9,045	49,201,122	5
Bridgeport, Conn					1,046	3,532,282	2,091	7,064,564	31
Brockton, Mass					22	239,050	586	1,252,440	114
Buffalo, N. Y					434	7,637,000	4,749	13,737,000	12
Butte, Mont					352	1,053,424	1,056	1,962,119	80
Cambridge, Mass			38	30,925	217	2,955,820	667	4,033,115	43
Camden, N. J			24	122,950	715	3,415,450	1,032	3,628,760	49
Canton, Ohio					163	1,784,750	1,348	3,869,655	45
Charleston, S. C					78	182,747	464	544,661	138
Chattanooga, Tenn					92	1,035,300	2,439	1,474,760	103
Chester, Pa			32	10,850	587	3,102,450	656	3,122,750	56
Cincinnati, Ohio					1,092	6,599,465	15,987	10,842,895	17
Cleveland, Ohio					836	15,573,655	14,022	33,108,260	6
Columbus, Ohio	4	20,400	82	13,920	1,054	4,683,840	3,141	7,194,240	29
Covington, Ky			104	10,344	266	688,129	554	844,308	125
Denver, Colo			433	134,890	[c] 2,555	[c] 4,000,440	2,578	4,014,590	44
Des Moines, Iowa					121	2,121,984	855	3,375,945	54
Detroit, Mich	35	587,925			1,892	21,798,185	16,489	51,068,310	3
Dubuque, Iowa			2	2,000	48	336,249	171	667,108	135
Duluth, Minn			5	7,481,000	164	8,611,187	1,963	10,223,598	20

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East St. Louis, Ill.					167	618,439	410	795,496	128
Elizabeth, N. J.					86	1,249,780	495	2,301,633	69
Elmira, N. Y.					65	1,336,100	222	1,704,900	91
Erie, Pa.					d 125	d 637,405	1,535	2,800,192	63
Evansville, Ind.	1	50,000	(f)	8,550	f 1	721,042	1	1,336,670	111
Fall River, Mass.					61	909,950	598	2,284,742	70
Fitchburg, Mass.			11	134,850	49	225,448	235	473,203	139
Flint, Mich.					182	1,855,567	3,002	4,733,447	39
Fort Wayne, Ind.					141	1,983,300	328	3,479,531	52
Fort Worth, Tex.					199	1,620,250	845	2,127,884	75
Galveston, Tex.			12	48,786	230	421,820	1,928	774,141	129
Grand Rapids, Mich.					206	2,206,290	1,748	3,519,245	51
Harrisburg, Pa.			21	131,675	448	1,793,695	529	1,930,923	84
Hartford, Conn.					352	5,054,025	1,423	7,383,163	27
Haverhill, Mass.			6	10,800	50	240,750	408	1,172,350	117
Hoboken, N. J.			8	603,715	123	1,709,112	228	1,789,750	87
Holyoke, Mass.					89	1,116,850	170	1,337,570	110
Houston, Tex.			10	282,959	483	1,387,019	3,449	3,086,871	60
Indianapolis, Ind.					690	3,037,572	5,746	8,934,694	24
Jacksonville, Fla.					149	976,791	617	1,558,924	96
Kalamazoo, Mich.					41	335,600	184	581,195	137
Kansas City, Kans.					21	225,294	612	748,430	130
Kansas City, Mo.			404	257,560	1,100	7,558,935	3,620	11,563,444	16
Knoxville, Tenn.					101	263,512	732	468,771	140
Lancaster, Pa.					322	1,022,677	323	1,023,677	120
Lawrence, Mass.					81	708,050	335	1,516,723	100
Lincoln, Nebr.			5	415	99	1,072,209	524	1,939,917	81
Little Rock, Ark.			19	159,560	143	770,008	601	1,293,452	112
Los Angeles, Cal.					1,607	6,771,109	7,565	15,036,045	11
Louisville, Ky.			117	1,445,740	553	2,336,870	2,299	3,853,140	46
Lowell, Mass.					110	656,120	831	1,492,973	102
Lynn, Mass.	3	115,100			78	861,495	621	1,520,427	99
McKeesport, Pa.					64	515,035	232	706,046	133
Macon, Ga.					118	454,273	633	670,576	134
Malden, Mass.					73	455,000	341	852,400	124
Manchester, N. H.			1	180	79	490,155	1,106	1,448,129	104
Milwaukee, Wis.	1	3,500	7	127,710	573	7,900,413	4,008	13,010,312	14
Minneapolis, Minn.	71	644,735			933	14,182,215	6,970	22,917,290	7
Mobile, Ala.					20	43,570	83	75,390	146
Montgomery, Ala.					136	158,728	1,512	444,929	142
Nashville, Tenn.			20	9,541	1,114	3,238,481	6,367	3,657,510	48
Newark, N. J.					1,097	7,006,745	3,627	10,236,316	19
New Bedford, Mass.					238	3,115,951	949	4,762,081	38
New Britain, Conn.					280	596,065	610	1,419,010	106
New Haven, Conn.			136	243,500	303	2,890,726	1,455	5,022,556	35
New York, N. Y.:									
Borough of Bronx			2,431	348,148	3,396	17,896,115	3,687	18,425,060	
Borough of Brooklyn					13,649	37,248,190	16,448	42,163,505	
Borough of Manhattan	738	9,930,510			4,409	133,982,444	4,448	134,078,044	1
Borough of Richmond			28	11,995	854	3,302,145	2,002	4,565,567	

For footnotes see p. 582.

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Building statistics of the leading cities of the United States in 1916—Continued.

City.	Fire-resisting buildings.						Grand total.		Rank in cost of building operations.
	Steel skeleton. Additions, alterations, and repairs.		Miscellaneous.		Total.				
	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	
Norfolk, Va.			105	69,911	325	2,205,464	674	2,712,988	65
Oakland, Cal.					87	1,713,755	3,683	5,368,290	34
Omaha, Nebr.			38	34,427	244	5,061,411	1,454	7,226,107	28
Passaic, N. J.					150	1,244,523	340	1,420,758	105
Paterson, N. J.			37	27,320	332	1,556,312	1,164	2,347,745	68
Pawtucket, R. I.					30	594,200	412	1,213,693	116
Philadelphia, Pa.	42	72,300			13,657	49,204,490	13,708	49,319,225	4
Portland, Maine.					86	801,555	576	1,653,742	93
Portland, Oreg.					794	3,555,420	4,351	6,272,865	32
Providence, R. I.					446	6,703,000	3,661	9,248,900	23
Pueblo, Colo.			19	54,122	161	416,194	221	436,520	143
Quincy, Ill.					44	217,870	103	339,090	145
Reading, Pa.	11	24,650	9	25,325	1,423	1,705,450	2,080	1,719,675	90
Richmond, Va.			51	123,710	1,350	3,909,325	2,155	4,927,396	37
Rochester, N. Y.			30	11,533	601	4,388,216	3,136	9,379,447	22
Sacramento, Cal.					337	1,496,810	1,229	2,102,158	77
Saginaw, Mich.					27	90,110	265	426,100	144
St. Joseph, Mo.					[a] 48	[a] 625,635	562	1,068,243	119
St. Louis, Mo.			[c] 3,616	[c] 458,357	7,776	15,233,103	8,550	15,444,103	10
St. Paul, Minn.					275	5,098,394	1,845	8,811,961	25
Salem, Mass.					84	856,300	470	1,554,124	97
Salt Lake City, Utah.					924	2,706,772	1,146	2,869,749	61
San Antonio, Tex.			80	45,107	192	1,414,514	1,737	2,283,638	71
San Diego, Cal.					[a] 68	[a] 728,259	1,425	1,824,162	85
San Francisco, Cal.					905	11,356,330	6,492	16,837,173	8
Savannah, Ga.			1	450,000	85	1,125,780	573	1,673,880	92
Schenectady, N. Y.			2	72,010	209	920,460	1,051	1,770,825	89
Scranton, Pa.					88	728,492	644	1,536,440	98
Seattle, Wash.			132	24,711	1,117	4,521,186	8,486	8,304,689	26
Sioux City, Iowa.					129	2,010,020	891	3,090,305	59
Somerville, Mass.			44	389,060	196	812,632	427	1,498,932	101

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Spokane, Wash					206	1,043,246	1,298	1,586,787	95
Springfield, Ill					146	1,297,942	674	2,126,537	76
Springfield, Mass					474	4,782,976	1,695	7,101,032	30
Superior, Wis					36	633,885	693	1,400,929	107
Syracuse, N. Y			14	2,645	154	242,160	1,809	2,556,008	66
Tacoma, Wash					224	790,124	1,372	1,617,981	94
Tampa, Fla					155	755,373	1,200	1,288,663	113
Terre Haute, Ind			7	490	109	426,403	621	816,270	126
Toledo, Ohio					322	3,560,830	4,293	9,692,268	21
Topeka, Kans					28	305,090	484	806,865	127
Troy, N. Y					107	872,246	394	1,125,961	118
Utica, N. Y					117	847,175	577	1,835,475	83
Washington, D. C			1,066	452,821	4,070	16,393,011	5,239	17,494,804	9
West Hoboken, N. J					54	403,674	140	462,518	141
Wheeling, W. Va					346	877,814	672	976,696	122
Wichita, Kans					91	1,367,925	343	1,998,805	79
Wilkes-Barre, Pa	1	29,800	3	2,125	223	770,830	887	1,213,605	115
Woonsocket, R. I			2	3,000	29	162,777	325	717,427	132
Worcester, Mass					[c] 901	[c] 3,730,318	1,816	6,164,871	33
Yonkers, N. Y			28	7,000	214	1,584,500	463	2,213,100	73
York, Pa			5	8,775	336	552,893	668	631,180	136
	927	11,530,345	10,639	28,543,045	105,611	615,436,356	308,498	[a] 852,842,397	
Percentage of total		1.35		3.35		72.16		100	

For footnotes see p. 582.

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Building statistics of the leading cities of the United States in 1916—Continued.

City.	Grand total.		Rank in cost of building operations.
	Number of permits or buildings.	Cost.	
Bay City, Mich.	655	$907,205	123
Chicago, Ill.	10,277	112,835,150	2
Dallas, Tex.	1,523	4,293,464	41
Davenport, Iowa	609	1,017,395	121
El Paso, Tex.	1,654	3,551,909	50
Jersey City, N. J.	1,036	5,005,243	36
Memphis, Tenn.	2,439	3,091,970	58
New Orleans, La.	1,015	3,117,604	57
Newton, Mass.	989	3,166,948	55
Oklahoma, Okla.	757	2,073,634	78
Peoria, Ill.	797	4,643,182	40
Pittsburgh, Pa.	4,175	13,554,810	13
South Bend, Ind.	926	1,396,501	108
Trenton, N. J.	(n)	2,256,156	72
Waterbury, Conn.	1,337	4,270,000	42
Wilmington, Del.	1,029	2,788,028	64
Youngstown, Ohio.	1,355	3,400,079	53
Grand total.	339,071	1,024,211,675	

[a] Additions, etc., to brick buildings for Chattanooga are included with additions, etc., to wooden buildings.
[b] All classes of new fire-resisting buildings for Binghamton, Cincinnati, Erie, and Providence are included with new brick buildings.
[c] Undistributed operations for all classes of buildings for Boston and St. Louis is included with miscellaneous for fire-resisting buildings.
[d] Additions, etc., to all classes of buildings for Cincinnati, Cleveland, and Erie are included with additions, etc., to wooden buildings.
[e] Additions, etc., to all classes of buildings for Denver and Worcester are included with additions, etc., to brick buildings.
[f] Number of permits or buildings for Evansville is given only for additions, etc., to steel skeleton buildings.
[g] Additions, etc., to brick buildings for Fall River and Pawtucket are included with new brick buildings, and the cost of additions to concrete buildings for Fall River are included with new concrete buildings.
[h] Additions, etc., to all classes of fire-resisting buildings for Providence are included with additions, etc., to brick buildings.
[i] Additions, etc., to fire-resisting buildings for St. Joseph and San Diego are included with additions, etc., to wooden buildings.
[k] Cost of new wooden buildings and of additions thereto not itemized for Somerville.
[l] Operations on wooden buildings were not separately classified for Topeka.
[m] Includes operations on wooden buildings costing $686,300 for Somerville and $503,865 for Topeka, not separately classified.
[n] Number of permits for Trenton not given.

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The 146 cities included in this table reported building operations costing $1,024,211,675 in 1916, and of this number 129 cities reported sufficient detail to permit the publication of statistics of operations by classes of structures. These 129 cities reported 308,498 permits or buildings that cost $852,842,397. Of this amount, new buildings of every variety cost $707,584,797, or more than four-fifths of the total; additions, alterations, and repairs cost $112,280,754, or more than one-eighth of the total; and miscellaneous operations cost $31,786,681, or nearly 4 per cent of the total. In addition, unclassified operations on wooden buildings costing $1,190,165, or 0.14 per cent of the total cost of all building operations in these cities, were reported by Somerville, Mass,. and Topeka, Kans.

It should be borne in mind that these statistics of building operations by kinds, especially in the totals, are only approximate, as many cities were unable to report strictly in accordance with the classification given in the table. It is believed, however, that the figures as published are accurate enough to give a good idea of the relative importance of the various kinds of operations enumerated.

The rank of the several cities in the different varieties of building operation is relative and not actual, as some of the cities for which no details can be published may have exceeded some of the cities reporting in cost of the classes of buildings.

Taken by classes, the new wooden buildings in these cities in 1916 cost $196,725,197, or 23 per cent of the total cost of all operations, and new brick buildings cost $312,545,908, or 37 per cent of the total. All other new buildings cost $198,313,692, or 23 per cent of the total. Of the total cost of new buildings, those constructed of wood constituted 28 per cent, and new fire-resisting buildings cost $510,859,600, or 72 per cent. The cost of new brick or hollow-tile buildings ($312,545,908) constituted 44 per cent of the cost of all new buildings. Of the cost of all additions, alterations, and repairs, $36,247,043, or 32 per cent, was for wooden buildings; $60,429,301, 54 per cent, was for brick or hollow-tile buildings; and $15,604,410, 14 per cent, was for all other fire-resisting buildings.

Operations on brick or hollow-tile buildings (new), additions, alterations, and repairs in these cities cost $372,975,209, or 44 per cent of the total cost of all operations in these cities. In addition to the brick or hollow tile used in the construction of brick buildings, large quantities are also used in foundations, in chimneys to wooden buildings, and in the construction of nearly all fire-resisting buildings.

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NATURAL GAS.[1]

By JOHN D. NORTHROP.

INTRODUCTION.

Although natural gas was first utilized commercially in the United States in 1821, the development of the natural-gas industry with which we are familiar to-day has taken place for the most part in the last 18 years. Since 1898 the value of the natural gas marketed in this country has increased steadily, amounting in 1916 to more than $120,000,000, a sum nearly eight times as great as that representing the market value of the gas utilized in 1898. Natural gas valued at more than three times the value of the entire output in 1898 was produced and marketed in 1916 in West Virginia alone; the value of the gas marketed from wells in Pennsylvania in 1916 was more than one and one-half times the value of the output in the entire country in 1898; the gas marketed from Ohio sources in 1916 was approximately equivalent in value to the total output in 1898; and Oklahoma, not even listed as a producer of natural gas in 1898, was credited in 1916 with an output equivalent to more than three-fourths the value of all the natural gas marketed in this country in 1898. This remarkable growth, although it has closely paralleled that of the petroleum industry in the same period, has differed in being so uniform and so devoid of spectacular features that few people aside from those directly interested in the natural-gas industry appreciate its present magnitude.

The casual reader may be interested in the fact that natural gas to the value of more than $120,000,000 was produced and utilized in the United States in 1916, but unless he recognizes that this sum is greater by $27,000,000 than the value of all the gold, nearly two and one-half times the value of all the silver, one and one-half times the value of all the lead, and one and one-seventh times the value of all the cement produced in this country in that year, he is likely to underestimate the importance of the annual contribution of the natural-gas industry to the mineral wealth of the country.

Since its organization in 1879 the United States Geological Survey has recognized the value of a permanent statistical record of the mining and mineral industries of the United States, and since 1884 it has prepared and issued annually a report on the natural-gas industry. The following report, the thirty-third in this series, comprises a statistical review of the production and consumption of natural gas in the United States in the calendar year 1916, an account of the principal developments in the gas fields of the several States, and brief notes on the trend of the natural-gas industry in foreign countries, so far as conditions can be ascertained.

[1] The statistical tables in this chapter, as in previous reports of this series, are the work of Miss Belle Hill, of the United States Geological Survey.

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The term "production," as applied in this report, is used in a restricted sense to designate only that portion of the natural gas actually produced during the year specified which found commercial utilization in that year. In this sense it is synonymous with "consumption," and, were there no interstate transportation of natural gas, the use of the former term would be unnecessary. As natural gas is freely transported from one State to another, however, the term "production" is convenient for designating the output of natural gas in a given State, irrespective of its place of consumption, and the term "consumption" is appropriate for designating the natural gas utilized in a given State, irrespective of its place of production.

The term "value," as used in this report, invariably designates the market value of the natural gas at the point of ultimate consumption, not of production. As a large proportion of the gas utilized in the United States is sold by the original owner to transportation companies at a flat rate per well, without regard to the volume of gas, effort to determine the value of gas at the point of production is impracticable. Where field meters are in use the price received by the producer ranges from 1½ to 15 cents a thousand cubic feet, depending on the relative abundance of gas in the particular locality and on the nature of the market, whether predominantly domestic or predominantly industrial.

PRODUCTION.

The volume of natural gas commercially utilized in the United States in 1916 was greater than that so utilized in any other year in the history of the natural-gas industry. The volume used, which amounted to 753,170,253,000 cubic feet, constituted a new record of production, exceeding by nearly 125,000,000,000 cubic feet, or 20 per cent, the former record, established in 1915.

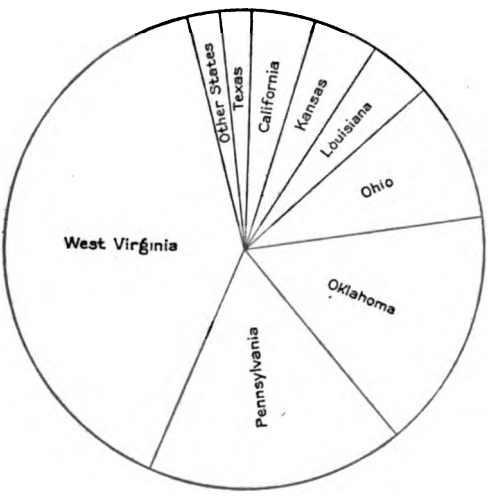

FIGURE 14.—Distribution by States of production of natural gas in the United States in 1916.

The market value of this gas likewise attained record proportions. It amounted to $120,227,468, a gain of $18,915,087, or 18.6 per cent, over the market value of the output in 1915. The average price per thousand cubic feet was 15.96 cents, a loss of 0.16 cent compared with 1915.

Credit for the increased production in 1916 belongs, in the order given, to West Virginia, Oklahoma, Pennsylvania, California, Louisiana, Kansas, Texas, and Arkansas, which together produced 132,000,000,000 cubic feet more gas in 1916 than in 1915. A significant increase, important locally, but unimportant as affecting the production of the entire country, was credited to Illinois,

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New York, and Montana. In only two States was there a significant decrease in the production of natural gas in 1916. The rapid exhaustion of the prolific Cleveland field, in Cuyahoga County, Ohio, resulted in a net loss of 9,600,000,000 cubic feet in the total volume of gas produced in Ohio, and the steady decline of the oil fields in Indiana caused a falling off of 600,000,000 cubic feet in the output of that State.

The general increase in the production of natural gas in the United States in 1916 is attributed principally to an enormous expansion of the natural-gas gasoline industry in all natural-gas producing States and to a greatly augmented demand for natural gas as fuel by industries engaged in the manufacture of munitions of war. The influence of this demand is shown in the increase in the volume of gas distributed to industrial consumers and in the increase in the value of gas consumed, its effect being sufficient to lower by 1 per cent the average price per thousand cubic feet of all gas sold in 1916 as compared with 1915.

CONSUMPTION.

The principal beneficiaries of the increased production of natural gas were, in the order named, Oklahoma, Pennsylvania, Ohio, Kansas, West Virginia, California, and Louisiana, which together consumed some 124,000,000,000 cubic feet more gas in 1916 than in 1915.

Of the total volume of natural gas produced and consumed in 1916, it is estimated that 235,380,764,000 cubic feet, or 31 per cent, was distributed to 2,362,494 domestic consumers at an average price of 28.63 cents a thousand cubic feet, and that the remaining 69 per cent, or 517,789,489,000 cubic feet, was distributed to 18,278 industrial consumers at an average price of 10.21 cents a thousand. Compared with 1915, these data show gain of 8 per cent in volume, of 8 per cent in number of consumers, and of 1 per cent in average unit price of gas supplied for domestic use, and a gain of 26 per cent in volume and of 5.5 per cent in average unit price, but a decrease of 0.4 per cent in the number of consumers of gas supplied for industrial use.

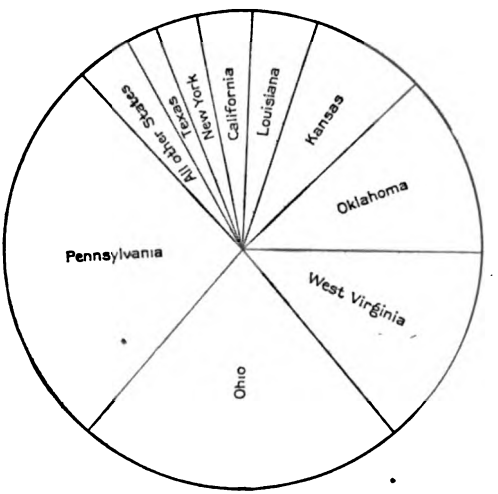

FIGURE 15.—Distribution by State of consumption of natural gas in the United States in 1916.

The proportion of natural gas supplied to industrial consumers in 1916 was 4 per cent larger than in 1915.

A further analysis of the statistics relating to domestic consumption of natural gas in 1916, based on the assumption that an average of 2,278,788 families were supplied with natural gas each month during that year, indicates that the average volume of gas utilized monthly

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by each family was 8,600 cubic feet and that the average monthly gas bill in each household was $2.46. These data suggest decided economies in the consumption of natural gas for domestic purposes in 1916, compared with the results of similar computations for 1915, which indicate an average monthly consumption per household of 10,200 cubic feet of gas, obtained at an average monthly cost of $2.89.

Analysis of the statistics of natural gas consumed for industrial purposes in 1916 shows that approximately 342,861,015,000 cubic feet of gas, or 66 per cent of the entire volume, valued at $37,661,184, was consumed directly for manufacturing purposes in furnaces, kilns, and ovens employed in the smelting of metals and the manufacture of cement, brick, pottery, and glass, and that the remaining 34 per cent of the gas, valued at $15,180,924, was consumed indirectly in engines and under boilers in the generation of power.

STATISTICS OF PRODUCTION AND CONSUMPTION.

The following tables show, by States, the statistics of natural gas produced and used in the United States from 1887 to 1916, inclusive:

Approximate value of natural gas produced and used in the United States, 1887–1916.

State.	1887	1888	1889	1890	1891	1892
Pennsylvania	$13,749,500	$19,282,375	$11,593,989	$9,551,025	$7,834,016	$7,376,281
New York	333,000	332,500	530,026	552,000	280,000	216,000
Ohio	1,000,000	1,500,000	5,215,669	4,684,300	3,076,325	2,136,000
West Virginia	120,000	120,000	12,000	5,400	35,000	70,500
Illinois			10,615	6,000	6,000	12,988
Indiana	600,000	1,320,000	2,075,702	2,302,500	3,942,500	4,716,000
Kansas			15,873	12,000	5,500	40,795
Missouri			35,687	10,500	1,500	3,775
California			12,680	33,000	30,000	55,000
Kentucky and Tennessee			2,580	30,000	38,993	43,175
Texas and Alabama			1,728			100
Arkansas and Wyoming			375		250	100
Other	15,000	75,000	1,600,175	1,606,000	250,000	200,000
	15,817,500	22,629,875	21,107,099	18,792,725	15,500,084	14,870,714

State.	1893	1894	1895	1896	1897	1898
Pennsylvania	$6,488,000	$6,279,000	$5,852,000	$5,528,610	$6,242,543	$6,806,742
New York	210,000	249,000	241,530	256,000	200,076	229,078
Ohio	1,510,000	1,276,100	1,255,700	1,172,400	1,171,777	1,488,308
West Virginia	123,000	395,000	100,000	640,000	912,528	1,334,023
Illinois	14,000	15,000	7,500	6,375	5,000	2,498
Indiana	5,718,000	5,437,000	5,203,200	5,043,635	5,009,208	5,060,989
Kansas	50,000	86,600	112,400	124,750	105,700	174,640
Missouri	2,100	4,500	3,500	1,500	500	145
California	62,000	60,350	55,000	55,682	50,000	65,337
Kentucky and Tennessee	68,500	89,200	98,700	99,000	15,090	7,875
Texas	50	50	20		90,000	103,133
Alabama						765
Arkansas and Wyoming	100	100	100	60	4,000	3,300
Utah	500	500	20,000	20,000		
Colorado		12,000	7,000	4,500		
South Dakota					20,000	20,000
Other	100,000	50,000	50,000	50,000		
	14,346,250	13,964,400	13,006,650	13,002,512	13,826,422	15,296,813

State.	1899	1900	1901	1902	1903	1904
Pennsylvania	$8,337,210	$10,215,412	$12,688,161	$14,352,188	$16,182,834	$18,139,914
New York	294,593	335,367	293,232	346,471	493,686	522,575
Ohio	1,866,271	2,178,234	2,147,215	2,355,458	4,479,040	5,315,564
West Virginia	2,335,864	2,959,032	3,954,472	5,390,181	6,882,359	8,114,249
Illinois	2,067	1,700	1,825	1,844	3,310	4,745
Indiana	6,690,370	7,254,539	6,954,566	7,081,344	6,098,364	4,342,409
Kansas	332,592	356,900	659,173	824,431	1,123,849	1,517,643
Missouri	290	547	1,328	2,154	7,070	6,285

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Approximate value of natural gas produced and used in the United States, 1887–1916—Continued.

State.	1899	1900	1901	1902	1903	1904
California	$86,891	$79,083	$67,602	$120,648	$104,521	$114,195
Texas, Alabama, Louisiana	8,000	20,000	18,577	14,953	13,851	14,082
Kentucky, Tennessee	125,745	286,242	270,871	365,656	390,601	322,404
Arkansas and Wyoming					2,460	6,515
Utah	1,480					
Colorado	3,500	1,800	1,800	1,900	14,140	14,300
Oklahoma				360	1,000	49,665
South Dakota		9,817	7,255	10,280	10,775	12,215
	20,074,873	23,698,674	27,066,077	30,867,863	35,807,880	38,496,760

State.	1905	1906	1907	1908	1909	1910
Pennsylvania	$19,197,336	$18,558,245	$18,844,156	$19,104,944	$20,475,207	$21,057,211
New York	623,251	672,795	766,157	959,280	1,222,666	1,678,720
Ohio	5,721,462	7,145,809	8,718,562	8,244,835	9,966,938	8,626,954
West Virginia	10,075,804	13,735,343	16,670,962	14,837,130	17,538,565	23,816,553
Illinois	7,223	87,211	143,577	446,077	644,401	613,642
Indiana	3,094,134	1,750,715	1,572,605	1,312,507	1,616,903	1,473,403
Kansas	2,261,836	4,010,986	6,198,583	7,691,587	8,293,846	7,755,367
Missouri	7,390	9,210	17,010	22,592	10,025	12,611
California	133,696	134,560	168,397	307,652	446,933	476,697
Texas, Alabama, Louisiana	14,409 1,500	150,695	178,276	236,837	453,253	956,683
Kentucky	237,290	287,501	380,176	424,271	485,192	456,293
Tennessee	300	300	300	350	350	300
Arkansas and Wyoming	21,135	34,500	126,582	164,930	226,925	301,151
Colorado	20,752	22,800				
Oklahoma	130,137	259,862	417,221	860,159	1,806,193	3,490,704
South Dakota	15,200	15,400	19,500	24,400	16,164	31,999
North Dakota			235	2,480	3,025	7,010
Oregon			100	250	50	
Iowa				93	50	40
Michigan					255	820
	41,562,855	46,873,932	54,222,399	54,640,374	63,206,941	70,756,158

State.	1911	1912	1913	1914	1915	1916
Pennsylvania	$18,520,796	$18,539,672	$21,695,845	$20,839,869	$21,139,605	$24,344,324
New York	1,418,767	2,343,379	2,425,633	2,600,352	2,335,252	2,524,115
Ohio	9,367,347	11,891,299	10,521,930	14,667,790	17,391,060	15,601,144
West Virginia	28,435,907	33,324,475	34,164,850	35,076,755	36,424,263	47,603,396
Illinois	687,726	616,467	574,015	437,275	350,371	396,357
Indiana	1,192,418	1,014,295	843,047	755,407	695,380	503,373
Kansas	4,854,534	4,264,706	3,288,394	3,340,025	4,037,011	4,855,399
Missouri	10,496	11,576	6,795	5,319	7,731	17,594
California	800,714	1,134,456	1,883,450	2,910,784	4,069,004	5,440,277
Kentucky	407,689	522,455	509,846	490,875	614,998	752,635
Tennessee	300	375	600	300	400	1,150
Texas	1,014,945	1,405,077	2,073,823	2,469,770	2,593,873	3,143,871
Louisiana, Alabama	858,145	1,747,379	2,119,948	2,227,999	2,163,934	2,660,445
South Dakota, North Dakota, Wyoming	16,984 5,738	30,412	31,166	27,220	36,445	31,573
Colorado	295,858	309,816	269,421	214,103	59,898	86,077
Arkansas					193,092	241,896
Oklahoma	6,731,770	7,406,528	7,436,389	8,060,089	9,195,804	11,983,774
Iowa	70	120	120	200	250	275
Michigan	1,330	1,470	1,405	1,442	1,510	948
Montana					2,500	38,855
	74,621,534	84,563,957	87,846,677	94,115,524	101,312,381	120,227,468

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Natural gas produced and consumed in the United States in 1915 and 1916.

State.	Produced.			Consumed.		
	Quantity (M cubic feet).	Price (cents per M cubic feet).	Value.	Quantity (M cubic feet).	Price (cents per M cubic feet).	Value.
1915.						
West Virginia	244,004,159	14.93	$36,424,263	94,976,705	7.85	$7,451,003
Pennsylvania	113,691,690	18.59	21,139,605	176,367,235	17.06	30,067,667
Ohio	79,510,032	21.87	17,391,060	146,724,989	21.74	31,900,764
Oklahoma	87,516,753	10.51	9,195,804	[a] 65,691,366	7.70	5,058,526
California	21,891,035	18.59	4,069,004	21,891,035	18.59	4,069,004
Kansas	27,045,908	14.93	4,037,011	[b] 48,871,295	16.73	8,174,289
Texas	13,323,747	19.47	2,593,873	13,323,747	19.47	2,593,873
New York	7,976,985	29.27	2,335,252	18,776,496	30.23	5,676,097
Louisiana	25,540,392	8.47	2,153,934	[c] 25,540,392	8.47	2,163,934
Indiana	2,260,733	30.76	695,380	4,519,244	34.13	1,542,604
Kentucky	1,667,423	36.88	614,998	7,746,353	25.08	1,942,423
Illinois	2,690,593	13.02	350,371	[d] 2,690,593	13.02	350,371
Arkansas	[e] 991,799	19.47	193,092	[e] 991,799	19.47	193,092
Wyoming, Colorado	341,842	17.52	59,898	341,842	17.52	59,898
South Dakota, Alabama, North Dakota	88,641	41.12	36,445	88,641	41.12	36,445
Missouri	27,645	27.97	7,731	27,645	27.97	7,731
Montana	5,555	45.00	2,500	5,555	45.00	2,500
Michigan	2,060	73.30	1,510	2,060	73.30	1,510
Tennessee	1,600	25.00	400	1,600	25.00	400
Iowa	250	100.00	250	250	100.00	250
	628,578,842	16.12	101,312,381	628,578,842	16.12	101,312,381
1916.						
West Virginia	299,318,907	15.90	$47,603,396	[f] 105,104,008	8.19	$8,610,084
Pennsylvania	129,925,150	18.74	24,344,324	201,460,893	17.38	35,015,695
Oklahoma	123,517,385	9.70	11,983,774	[a] 93,704,221	7.54	7,062,142
Ohio	69,888,070	22.32	15,601,144	169,480,011	22.06	37,394,410
Louisiana	32,080,975	8.29	2,660,445	[c] 32,080,975	8.29	2,660,445
Kansas	31,710,438	15.31	4,855,389	[b] 60,564,112	16.07	9,731,518
California	31,643,266	17.19	5,440,277	31,643,266	17.19	5,440,277
Texas	15,809,579	19.89	3,143,871	15,809,579	19.89	3,143,871
New York	8,594,187	29.37	2,524,115	20,594,123	30.26	6,230,826
Illinois	3,533,701	11.22	396,357	[d] 3,533,701	11.22	396,357
Arkansas	2,387,935	10.13	241,896	[g] 3,347,398	8.59	287,399
Kentucky	2,106,542	35.73	752,635	9,887,956	23.58	2,331,687
Indiana	1,715,499	29.34	503,373	5,021,364	34.78	1,746,285
Wyoming, Colorado	575,044	14.97	86,077	575,044	14.97	86,077
Montana	213,315	18.21	38,855	213,315	18.21	38,855
South Dakota, Alabama, North Dakota	77,478	40.75	31,573	77,478	40.75	31,573
Missouri	69,236	25.41	17,594	69,236	25.41	17,594
Tennessee	2,000	57.50	1,150	2,000	57.50	1,150
Michigan	1,298	73.04	948	1,298	73.04	948
Iowa	275	100.00	275	275	100.00	275
	753,170,253	15.96	120,227,468	753,170,253	15.96	120,227,468

[a] Includes gas piped from Oklahoma and consumed in Missouri.
[b] Includes gas piped from Kansas and consumed in Missouri.
[c] Includes gas piped from Louisiana and consumed in Arkansas and Texas.
[d] Includes gas piped from Illinois and consumed in Indiana.
[e] Includes gas piped from Oklahoma and consumed in Arkansas.
[f] Includes gas piped from West Virginia and consumed in Maryland.
[g] Includes gas piped from Oklahoma.

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Distribution of natural gas consumed in the United States in 1915.

State.	Number of producers.	Consumers.		Gas consumed.		
				Domestic.		
		Domestic.	Industrial.	Quantity (M cubic feet).	Price (cents per M cubic feet).	Value.
Ohio	2,499	773,548	5,621	77,087,545	29.35	$22,626,560
Pennsylvania	1,396	440,673	4,696	51,348,384	27.28	14,009,226
Kansas [a]	371	201,133	1,446	20,629,792	25.83	5,329,260
West Virginia [b]	506	115,908	1,910	17,893,105	18.34	3,281,532
New York	346	153,972	815	17,309,353	31.19	5,398,084
Oklahoma [c]	434	67,874	1,551	10,047,410	17.97	1,805,826
California	59	207,673	257	4,210,915	66.70	2,808,781
Texas	65	59,386	677	4,926,607	37.72	1,858,308
Louisiana [d]	57	30,144	597	3,836,419	26.87	1,030,893
Kentucky	86	84,666	117	4,924,209	34.19	1,683,390
Indiana [e]	999	44,012	438	3,505,354	35.89	1,258,019
Illinois [f]	226	8,610	134	704,696	27.25	192,050
Arkansas [g]	9	5,797	59	624,264	25.57	159,606
Wyoming	17	599	10	69,439	34.87	24,211
Colorado	14	7	8			
South Dakota	28	399	6			
Alabama	6	440	1	57,841	47.06	27,220
North Dakota	12	42	2			
Missouri	44	174	9	22,978	28.12	6,461
Montana	2	1	1	(h)	.....	(h)
Michigan	16	14	2	960	100.00	960
Tennessee	8	6	1	1,200	25.00	300
Iowa	5	3	.....	250	100.00	250
	7,205	2,195,081	18,358	217,200,721	28.32	61,500,937

State.	Gas consumed.					
	Industrial.			Total.		
	Quantity (M cubic feet).	Price (cents per M cubic feet).	Value.	Quantity (M cubic feet).	Price (cents per M cubic feet).	Value.
Ohio	69,637,444	13.32	$9,274,204	146,724,989	21.74	$31,900,764
Pennsylvania	125,018,851	12.86	16,078,441	176,367,235	17.06	30,087,667
Kansas [a]	28,241,503	10.07	2,845,029	48,871,295	16.73	8,174,289
West Virginia [b]	77,083,600	5.41	4,169,471	94,976,705	7.85	7,451,003
New York	1,467,143	18.95	278,013	18,776,496	30.23	5,676,097
Oklahoma [c]	55,643,956	5.85	3,252,700	65,691,366	7.70	5,058,526
California	17,680,120	7.13	1,260,223	21,891,035	18.59	4,069,004
Texas	8,397,140	8.76	735,565	13,323,747	19.47	2,593,873
Louisiana [d]	21,703,973	5.22	1,133,041	25,540,392	8.47	2,163,934
Kentucky	2,822,144	9.18	259,033	7,746,353	25.08	1,942,423
Indiana [e]	1,013,890	28.07	284,585	4,519,244	34.13	1,542,604
Illinois [f]	1,985,897	7.97	158,321	2,690,593	13.02	350,371
Arkansas [g]	367,535	9.11	33,486	991,799	19.47	193,092
Wyoming	272,403	13.10	35,687	341,842	17.52	59,898
Colorado						
South Dakota						
Alabama	30,800	29.95	9,225	88,641	41.12	36,445
North Dakota						
Missouri	4,667	27.21	1,270	27,645	27.97	7,731
Montana	5,555	45.00	2,500	5,555	45.00	2,500
Michigan	1,100	50.00	550	2,060	73.30	1,510
Tennessee	400	25.00	100	1,600	25.00	400
Iowa	.....	.....	.....	250	100.00	250
	411,378,121	9.68	39,811,444	628,578,842	16.12	101,312,381

[a] Includes the consumption of gas piped from Kansas to Missouri.
[b] Includes the consumption of gas piped from West Virginia to Maryland.
[c] Includes some gas piped from Oklahoma to Missouri.
[d] Includes the consumption of gas piped to Texas from Louisiana and to Arkansas from Louisiana.
[e] Includes the consumption of gas piped from Indiana to Chicago, Ill.
[f] Includes the consumption of gas piped from Illinois to Vincennes, Ind.
[g] Includes the consumption of gas piped from Oklahoma to Arkansas.
[h] Included with industrial consumption.

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Distribution of natural gas consumed in the United States in 1916.

State.	Number of producers.	Consumers.		Gas consumed.		
				Domestic.		
		Domestic.	Industrial.	Quantity (M cubic feet).	Price (cents per M cubic feet).	Value.
Ohio	2,503	836,828	4,602	81,657,622	29.78	$25,208,751
Pennsylvania	1,586	463,264	4,676	55,605,995	27.26	15,159,479
Kansas [a]	414	202,222	1,354	20,876,693	25.45	5,314,011
West Virginia [b]	544	123,860	1,963	18,779,871	18.05	3,389,400
Oklahoma [c]	544	79,724	2,327	10,723,336	17.87	1,915,758
New York	360	159,886	676	18,824,887	31.22	5,877,898
California	87	242,775	175	5,629,022	63.93	3,598,695
Texas	83	68,218	931	5,423,295	38.96	2,112,893
Louisiana [d]	73	32,257	679	3,890,552	29.54	1,149,336
Kentucky	107	85,583	125	5,860,235	33.55	1,965,892
Indiana	995	44,118	471	3,357,872	37.50	1,259,245
Illinois [e]	218	14,485	121	635,298	26.72	169,729
Arkansas [f]	17	6,399	135	713,047	21.49	153,208
Wyoming	20	749	13	156,512	24.62	38,530
Colorado	17	10	9			
Montana	5	727	6	137,615	22.89	31,500
South Dakota	30	399	4			
Alabama	9	355	1	43,503	53.83	23,418
North Dakota	13	42	2			
Missouri	45	574	4	63,936	25.48	16,294
Tennessee	9	7	3	600	75.00	450
Michigan	12	9	1	598	100.00	598
Iowa	6	3	.....	275	100.00	275
	7,697	2,362,494	18,278	235,380,764	28.63	67,385,360

State.	Gas consumed.					
	Industrial.			Total.		
	Quantity (M cubic feet).	Price (cents per M cubic feet).	Value.	Quantity (M cubic feet).	Price (cents per M cubic feet).	Value.
Ohio	84,822,389	14.37	$12,185,659	169,480,011	22.06	$37,394,410
Pennsylvania	145,854,898	13.61	19,856,216	201,460,893	17.38	35,015,695
Kansas [a]	39,687,419	11.13	4,417,507	60,564,112	16.07	9,731,518
West Virginia [b]	86,324,137	6.05	5,220,684	105,104,008	8.19	8,610,084
Oklahoma [c]	82,980,885	6.20	5,146,384	93,704,221	7.54	7,062,142
New York	1,769,236	19.95	352,928	20,594,123	30.26	6,230,826
California	26,014,244	7.08	1,841,582	31,643,266	17.19	5,440,277
Texas	10,386,284	9.93	1,030,978	15,809,579	19.89	3,143,871
Louisiana [d]	28,190,423	5.36	1,511,109	32,080,975	8.29	2,660,445
Kentucky	4,027,721	9.08	365,795	9,887,956	23.58	2,331,687
Indiana	1,663,492	29.28	487,040	5,021,364	34.78	1,746,285
Illinois [e]	2,898,403	7.82	226,628	3,533,701	11.22	396,357
Arkansas [f]	2,634,351	5.09	134,191	3,347,398	8.59	287,399
Wyoming	418,532	11.36	47,547	575,044	14.97	86,077
Colorado						
Montana	75,700	9.72	7,355	213,315	18.21	38,855
South Dakota						
Alabama	33,975	24.00	8,155	77,478	40.75	31,573
North Dakota						
Missouri	5,300	24.53	1,300	69,236	25.41	17,594
Tennessee	1,400	50.00	700	2,000	57.50	1,150
Michigan	700	50.00	350	1,298	73.04	948
Iowa	.....	.....	.....	275	100.00	275
	517,789,489	10.21	52,842,108	753,170,253	15.96	120,227,468

[a] Includes the consumption of gas piped from Kansas to Missouri.
[b] Includes the consumption of gas piped from West Virginia to Maryland.
[c] Includes some gas piped from Oklahoma to Missouri.
[d] Includes the consumption of gas piped to Texas and to Arkansas from Louisiana.
[e] Includes the consumption of gas piped from Illinois to Vincennes, Ind.
[f] Includes the consumption of gas piped from Oklahoma to Arkansas.

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Distribution of natural gas consumed for industrial purposes in the United States in 1915.

State.	Industrial consumers.			Gas consumed.		
				Manufacturing.		
	Manufacturing.	Other industrial (power).	Total.	Quantity (M cubic feet).	Price (cents per M cubic feet).	Value.
Pennsylvania	2,032	2,664	4,696	113,959,748	12.83	$14,618,980
Ohio	3,500	2,121	5,621	53,199,691	13.34	7,095,763
West Virginia	1,005	905	1,910	56,277,012	5.24	2,950,182
Oklahoma	323	1,228	1,551	28,336,632	5.25	1,489,021
Kansas	517	929	1,446	16,276,317	9.77	1,590,150
California		257	257			
Louisiana	93	504	597	2,455,305	7.56	185,501
Texas	56	621	677	1,244,925	6.46	80,441
Indiana	341	97	438	777,902	29.73	231,334
New York	28	787	815	246,986	17.96	44,357
Kentucky	36	81	117	2,424,063	8.38	203,184
Illinois	5	129	134	181,168	7.42	13,443
Arkansas	3	56	59	(a)		(a)
Wyoming		10	10			
Colorado		8	8			
South Dakota		6	6			
Alabama		1	1			
North Dakota		2	2			
Missouri		9	9			
Montana		1	1			
Michigan		2	2			
Tennessee		1	1			
	7,939	10,419	18,358	275,379,749	10.35	28,502,356

State.	Gas consumed.					
	Other industrial (power).			Total industrial.		
	Quantity (M cubic feet).	Price (cents per M cubic feet).	Value.	Quantity (M cubic feet).	Price (cents per M cubic feet).	Value.
Pennsylvania	11,059,103	13.19	$1,459,461	125,018,851	12.86	$16,078,441
Ohio	16,437,753	13.25	2,178,441	69,637,444	13.32	9,274,204
West Virginia	20,806,588	5.86	1,219,289	77,083,600	5.41	4,169,471
Oklahoma	27,307,324	6.46	1,763,679	55,643,956	5.85	3,252,700
Kansas	11,965,186	10.48	1,254,879	28,241,503	10.07	2,845,029
California	17,680,120	7.13	1,260,223	17,680,120	7.13	1,260,223
Louisiana	19,248,668	4.92	947,540	21,703,973	5.22	1,133,041
Texas	7,152,215	9.16	655,124	8,397,140	8.76	735,565
Indiana	235,988	23.01	53,251	1,013,890	28.07	284,585
New York	1,220,157	19.15	233,656	1,467,143	18.95	278,013
Kentucky	398,081	14.03	55,849	2,822,144	9.18	259,033
Illinois	1,804,729	8.03	144,878	1,985,897	7.97	158,321
Arkansas	367,535	9.11	33,486	367,535	9.11	33,486
Wyoming	272,403	13.10	35,687	272,403	13.10	35,687
Colorado						
South Dakota	30,800	29.95	9,225	30,800	29.95	9,225
Alabama						
North Dakota						
Missouri	4,667	27.21	1,270	4,667	27.21	1,270
Montana [b]	5,555	45.00	2,500	5,555	45.00	2,500
Michigan	1,100	50.00	550	1,100	50.00	550
Tennessee	400	25.00	100	400	25.00	100
	135,998,372	8.32	11,309,088	411,378,121	9.68	39,811,444

[a] Included in "Other industrial."

[b] Includes domestic consumption.

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Distribution of natural gas consumed for industrial purposes in the United States in 1916.

State.	Industrial consumers.			Gas consumed.		
				Manufacturing.		
	Manufacturing.	Other industrial (power).	Total.	Quantity (M cubic feet).	Price (cents per M cubic feet).	Value.
Pennsylvania	1,801	2,875	4,676	131,571,641	12.71	$18,035,430
Ohio	2,327	2,275	4,602	66,615,184	14.25	9,340,974
West Virginia	913	1,050	1,963	61,597,981	5.67	3,491,136
Oklahoma	366	1,961	2,327	46,246,844	5.84	2,701,135
Kansas	75	1,279	1,354	25,434,022	10.84	2,757,320
California		175	175			
Louisiana	94	585	679	3,158,555	7.59	239,806
Texas	45	886	931	1,608,948	7.30	117,430
Indiana	403	68	471	1,550,489	29.89	463,501
Kentucky	38	87	125	3,563,704	8.56	305,164
New York	14	662	676	456,776	23.16	105,777
Illinois	1	120	121	(a)		(a)
Arkansas	57	78	135	2,056,871	4.73	97,279
Wyoming	1	12	13	(a)		(a)
Colorado		9	9			
South Dakota		4	4			
Alabama		1	1			
North Dakota		2	2			
Montana	1	5	6	(a)		(a)
Missouri		4	4			
Tennessee		3	3			
Michigan		1	1			
	6,136	12,142	18,278	342,861,015	10.98	37,651,154

State	Gas consumed.					
	Other industrial (power).			Total industrial.		
	Quantity (M cubic feet).	Price (cents per M cubic feet).	Value.	Quantity (M cubic feet).	Price (cents per M cubic feet).	Value.
Pennsylvania	14,283,257	12.75	$1,820,777	145,854,898	13.61	$19,856,216
Ohio	19,207,205	14.78	2,838,685	84,822,389	14.37	12,185,659
West Virginia	24,726,156	7.00	1,729,548	86,324,137	6.05	5,220,684
Oklahoma	36,734,041	6.66	2,445,226	82,980,885	6.20	5,146,384
Kansas	14,253,397	11.65	1,659,987	39,687,419	11.13	4,417,507
California	26,014,244	7.08	1,841,582	26,014,244	7.08	1,841,582
Louisiana	25,031,868	5.06	1,271,343	28,190,423	5.36	1,511,109
Texas	8,777,336	10.41	913,548	10,386,284	9.93	1,030,978
Indiana	113,003	20.83	23,539	1,663,492	29.28	487,040
Kentucky	464,017	13.07	60,631	4,027,721	9.08	365,795
New York	1,312,460	18.83	247,151	1,769,236	19.95	352,928
Illinois	2,898,403	7.82	226,628	2,898,403	7.82	226,628
Arkansas	577,480	6.40	36,972	2,634,351	5.09	134,191
Wyoming	418,532	11.36	47,547	418,532	11.36	47,547
Colorado						
South Dakota						
Alabama	33,975	24.00	8,155	33,975	24.00	8,155
North Dakota						
Montana	75,700	9.72	7,355	75,700	9.72	7,355
Missouri	5,300	24.53	1,300	5,300	24.53	1,300
Tennessee	1,400	50.00	700	1,400	50.00	700
Michigan	700	50.00	350	700	50.00	350
	174,928,474	8.68	15,180,924	517,789,489	10.21	52,842,108

a Included in "Other industrial."

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Value of natural gas consumed in the United States, 1911–1916.

State.	1911	1912	1913	1914	1915	1916
Pennsylvania	$23,940,001	$26,486,302	$28,709,565	$28,439,324	$30,087,667	$35,015,695
Ohio	22,792,270	27,196,162	27,055,824	29,936,642	31,900,764	37,394,410
West Virginia	[a] 6,240,152	[a] 7,001,331	[a] 7,333,956	[a] 7,334,690	[a] 7,451,003	[a] 8,610,084
Kansas	[b] 9,493,701	[b] 8,521,858	[b] 6,983,802	[b] 7,163,746	[b] 8,174,289	[b] 9,731,518
New York	4,276,324	4,866,821	4,888,412	5,510,204	5,676,097	6,230,826
Oklahoma	2,092,603	3,149,376	3,740,981	4,226,318	5,058,526	7,062,142
Indiana	[c] 1,192,418	[c] 1,014,295	[c] 948,278	[c] 1,422,880	[c] 1,542,604	1,746,285
Texas	1,014,945	1,405,077	2,073,823	2,469,770	2,593,873	3,143,871
Louisiana	[d] 858,145	[d] 1,747,379	[d] 2,119,948	[d] 2,227,999	[d] 2,163,934	[d] 2,660,445
Alabama						
South Dakota	16,984	30,412	31,166	27,220	36,445	31,573
North Dakota	5,738					
Kentucky	901,759	1,070,664	1,225,116	1,787,308	1,942,423	2,331,687
California	800,714	1,134,456	1,883,450	2,910,784	4,069,004	5,440,277
Illinois	[e] 687,726	[e] 616,467	[e] 574,015	[e] 437,275	[e] 350,371	[e] 396,357
Missouri	10,496	11,576	6,795	5,319	7,731	17,594
Wyoming	295,858	309,816	269,421	214,103	59,898	86,077
Colorado						
Arkansas					193,092	[f] 287,399
Montana					2,500	38,855
Michigan	1,330	1,470	1,405	1,442	1,510	948
Tennessee	300	375	600	300	400	1,150
Iowa	70	120	120	200	250	275
	74,621,534	84,563,957	87,846,677	94,115,524	101,312,381	120,227,468

[a] Includes value of gas piped from West Virginia to Maryland.
[b] Includes value of gas piped from Kansas to Missouri in 1908, 1909, 1914, 1915 and 1916, and from Kansas and Oklahoma to Missouri in 1910, 1911, 1912, and 1913.
[c] A portion of this was consumed in Chicago, Ill.
[d] Includes value of gas piped from Louisiana to Texas and Arkansas.
[e] Includes value of gas produced in Illinois and consumed in Vincennes, Ind.
[f] Includes value of gas piped from Oklahoma to Arkansas.

COMBINED VALUE OF NATURAL GAS AND PETROLEUM.

The following table shows the value of natural gas and of petroleum and their combined value in 1915 and 1916, by States, arranged in the order of the value of the combined production:

Value of natural gas and petroleum produced in the United States in 1915 and 1916.

State.	Natural gas.	Crude petroleum.	Total.
1915.			
Oklahoma	$9,195,804	$56,706,133	$65,901,937
West Virginia	36,424,263	14,468,278	50,892,541
California	4,069,004	36,558,439	40,627,443
Pennsylvania	21,139,605	12,431,353	33,570,958
Ohio	17,391,060	10,061,493	27,452,553
Illinois	350,371	18,655,850	19,006,221
Texas	2,593,873	13,026,925	15,620,798
Louisiana	2,163,934	10,804,653	12,968,587
Kansas	4,037,011	1,702,891	5,739,902
New York	2,335,252	1,390,325	3,725,577
Wyoming	62,398	2,217,018	2,462,901
Colorado		183,485	
Montana			
Indiana	695,380	813,395	1,508,775
Kentucky	614,998	418,357	1,033,355
Arkansas	203,728		203,728
Alabama			
Missouri	7,731		
Michigan	1,510	24,295	33,536
Alaska			
South Dakota	25,809		25,809
North Dakota			
Tennessee	400		400
Iowa	250		250
	101,312,381	179,462,890	280,775,271

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Value of natural gas and petroleum produced in the United States in 1915 and 1916—Contd.

State.	Natural gas.	Crude petroleum.	Total.
1916.			
Oklahoma	$11,963,774	$128,463,805	$140,447,579
West Virginia	47,608,396	21,914,080	69,517,476
California	5,440,277	53,702,733	59,143,010
Pennsylvania	24,344,324	19,149,855	43,494,179
Ohio	15,601,144	16,154,940	31,756,084
Illinois	306,357	29,237,168	29,633,525
Texas	3,143,871	25,760,335	28,904,206
Louisiana	2,660,445	14,669,774	17,330,219
Kansas	4,855,389	10,339,958	15,195,347
Wyoming	86,077	5,644,080	5,947,296
Colorado		217,139	
New York	2,524,115	2,190,195	4,714,310
Kentucky	752,635	2,189,812	2,943,597
Tennessee	1,150		
Indiana	503,373	1,207,565	1,710,938
Arkansas	241,896		241,896
Montana	38,855	44,019	82,874
South Dakota	31,573		31,573
Alabama			
North Dakota			
Missouri	17,594	(a)	33,227
Michigan	948	(a)	
Alaska		(a)	
Iowa	275		
Undistributed		14,410	
	120,227,468	330,899,868	451,127,336

a Included in "Undistributed."

SUMMARY OF WELLS DRILLED.

Wells drilled for natural gas in 1916.

State.	Productive Dec. 31, 1915.	Drilled in 1916.			Abandoned in 1916.	Productive Dec. 31, 1916.
		Gas.	Dry.	Total.		
Alabama	17	2	5	7		19
Arkansas	100	25	14	39	5	120
California	108	7		7	10	105
Colorado	6	7		7		13
Illinois	372	36	126	162	65	343
Indiana	2,112	43	14	57	188	1,967
Iowa	6	1		1	1	6
Kansas	2,443	461	193	654	391	2,513
Kentucky	262	13	7	20	9	266
Louisiana	253	48	47	95	38	263
Michigan	12				4	8
Missouri	58		1	1	5	53
Montana	5	7	2	9		12
New York	2,046	106	35	141	84	2,068
North Dakota	15	3		3	5	13
Ohio	6,064	593	204	797	603	6,054
Oklahoma	1,229	386	231	617	206	1,409
Pennsylvania	13,431	1,009	252	1,261	523	13,917
South Dakota	31				2	29
Tennessee	8	1		1		9
Texas	214	77	113	190	34	257
West Virginia	7,718	1,055	161	1,216	265	8,508
Wyoming	36	9	3	12	8	37
	36,546	3,889	1,408	5,297	2,446	37,989

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ACREAGE CONTROLLED BY NATURAL-GAS PRODUCERS.

Land controlled by natural-gas producers in the United States in 1915 and 1916, in acres.

State.	1915				1916			
	In fee.	Leased.	Gas rights.	Total.	In fee.	Leased.	Gas rights.	Total.
Alabama	130	156,800	.....	156,930	90	77,660	.....	77,750
Arkansas	500	51,337	.....	51,837	695	96,919	.....	97,614
California	3,042	4,050	20,640	27,732	4,645	582	14,476	19,703
Colorado	3,441	2,300	.....	5,741	2,566	2,300	.....	4,866
Illinois	282	182,107	24,046	206,435	318	245,443	1,300	247,061
Indiana	85,678	79,182	1,004	165,864	90,112	77,371	2,627	170,110
Kansas	26,017	326,735	11,877	366,629	29,677	611,679	8,874	650,230
Kentucky	8,161	144,727	.....	152,888	8,658	238,409	510	247,577
Louisiana	12,138	221,913	20,474	254,525	17,102	385,870	20,340	423,312
Missouri	933	.....	.....	933	933	1,500	.....	2,433
Montana	920	19,840	.....	20,760	280	48,640	.....	48,920
New York	10,318	530,262	6,708	547,288	10,070	460,610	6,275	476,955
Ohio	30,090	1,479,234	9,905	1,519,229	33,889	1,513,426	10,916	1,558,231
Oklahoma	19,557	1,224,777	48,258	1,292,592	32,946	1,629,571	37,504	1,700,021
Pennsylvania	178,419	1,619,993	375,991	2,174,403	179,753	1,837,648	380,717	2,398,118
Tennessee	.....	5,500	.....	5,500	7	4,000	.....	4,007
Texas	14,858	457,955	16,757	489,570	25,304	835,591	16,387	877,372
West Virginia	124,333	2,399,225	660,687	3,184,245	237,033	3,116,042	513,298	3,866,373
Wyoming	2,658	21,688	.....	24,346	2,490	19,838	6,800	29,128
	523,575	8,927,625	1,196,342	10,647,542	676,658	11,203,099	1,020,024	12,899,781

NATURAL-GAS INDUSTRY BY STATES.

NEW YORK.

GENERAL STATEMENT.

Although occupying a statistical position of only moderate importance among the States that contribute to the natural-gas supply of this country, New York has the distinction of being the first State to recognize the utility of this gift of nature and to make use of it for fuel and illumination. Since 1821, the year in which natural gas was first obtained from a well 1½ inches in diameter and 27 feet deep put down within the borough limits of Fredonia, Chautauqua County, and was used for heat and light in that town, New York has been a factor in the natural-gas industry. Its annual production, though now less than 2 per cent of the total volume of natural gas utilized annually in the entire United States, represents a contribution to the mineral wealth of the State valued in excess of $2,000,000 a year. Natural gas is produced commercially in 16 counties in the central and western parts of New York. It is obtained from sandstone, shale, and limestone strata in the succession, of rocks between the Potsdam sandstone of the Cambrian system and the Chemung formation of the Devonian system. In Allegany, Cattaraugus, and Steuben counties, where the gas is associated for the most part with petroleum, the supply is derived principally from the Chemung and the underlying Portage formation. In Chautauqua County gas is obtained from these formations as well as from the lower-lying Medina group of the Silurian system, which is the principal source of the gas produced in the northern part of that county and in Erie, Genesee, Niagara, Orleans, Monroe, and Livingston counties. In Wyoming, Ontario, Onondaga, and Oswego

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counties gas in relatively small volume is obtained from the Trenton limestone of the Ordovician system, and in Chemung County gas is obtained from glacial drift.

PRODUCTION.

As a consequence principally of increased activity in the quest of petroleum, the volume of natural gas produced commercially in New York in 1916 exceeded the output in 1915 by 617,202,000 cubic feet, or nearly 8 per cent. The value of this gas at the point of ultimate consumption was $2,524,115, a gain of $188,863, or fully 8 per cent, over the value of the production in 1915. This gain is accounted for in part by the increased volume of gas produced and in part by a gain of 0.1 cent in the average price per thousand at which the gas was sold, the latter figure being 27.37 cents in 1916, and 27.27 cents in 1915.

Interest in the development of natural gas outside the areas in Allegany and Cattaraugus counties, where its production is incident to the quest for petroleum, led to the drilling of many new wells in the territory adjacent to Lake Erie, in Erie and Chautauqua counties. Although the average capacity of commercial gas wells in this area is less than 100,000 cubic feet a day each, the value of the field lies in the exceptionally long life of the wells. In many parts of this area gas is still being used from wells drilled 25 and 30 years ago. Drilling in the vicinity of Gowanda, Erie County, in 1916, was rewarded by a large increase in the supply of gas available for distribution in the towns of Gowanda and Collins. Production in this locality is derived principally from the white sand of the Medina group, reached at an average depth of 1,900 feet.

Near Dunkirk, Chautauqua County, considerable interest was aroused in the efforts of the Frost Gas Co. to determine the possibilities of natural-gas production in the Trenton limestone of that locality. A well on the Cassity farm east of Dunkirk that failed to yield gas in commercial quantities in the sands of the Medina group was selected by this company for a deep test. It was drilled to a total depth of about 4,000 feet and reluctantly abandoned in October because of inability to recover drilling tools unfortunately lost at that depth—some distance above the depth at which the Trenton limestone is believed to lie in that locality.

In addition to the wells from which gas is obtained for commercial distribution in cities and towns in western New York, there are in service throughout this area many wells of small capacity that yield only enough gas for domestic uses by one or at most three families each.

Developments in 1916 in the Pavilion district in Genesee County were without notable consequence, the completion of six new gas wells being sufficient to assure an adequate supply of gas to the towns and villages dependent on this field.

In Livingston County no wells were added in 1916 to the group that supplies a part of the fuel requirements of the village of Caledonia from wells that have been in service from 12 to 16 years and that still show a closed pressure of about 300 pounds to the square inch, though the volume of gas available from individual wells is small.

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Five new gas wells were drilled in 1916 in the Churchville district in Monroe County, from which gas is piped to consumers in Churchville and Bergen.

In Ontario, Yates, Schuyler, and Chemung counties conditions were essentially unchanged in 1916. Aside from the Ontario County gas distributed commercially in the villages of Gorham, Naples, Honeoye Falls, Lima, Holcomb, and Rushville, and the Schuyler County gas distributed in Watkins and Montour Falls, the gas produced in these counties is from individual wells, which furnish only enough gas for fuel and illumination in one or two residences each.

In the northern part of Onondaga County drilling in the Baldwinsville district resulted in the completion of three additional gas wells in 1916, and in the northern part of Oswego County four gas wells were added to the group from which gas is supplied to consumers in the villages of Lacona and Sandy Creek.

Near the village of Groton in Tompkins County, the quest of natural gas for use as fuel in the works of the Corona Typewriter Co. resulted in the reported discovery in October of a small flow of gas at a depth of 1,450 feet, in a test drilled 3 miles north of that village.

With the exception of a small volume transported across the State boundary and consumed in Bradford, Pa., all the gas produced in New York in 1916 was consumed within the State.

The total number of gas wells in service in New York at the end of 1916 was 2,068, a net increase of 22 wells during the year.

CONSUMPTION.

The estimated consumption of natural gas in New York in 1916 was 20,594,123,000 cubic feet, a gain of 1,817,627,000 cubic feet, or nearly 10 per cent, over the volume consumed in 1915. The value of this gas at the point of consumption was $6,230,826, a gain of $554,729, or a little less than 10 per cent, over the value of the consumption in 1915. The average price per thousand paid by all consumers of natural gas in New York in 1916 was 30.26 cents, a gain of 0.03 cent over the unit price in 1915. All classes of consumers considered, the average volume of natural gas used by each consumer of this fuel in New York in 1916 was 128,000 cubic feet, and the average cost of the service to each consumer was $39 a year.

About 18,824,887,000 cubic feet, or 91 per cent of the gas consumed, was supplied to 159,886 domestic consumers at an average price of 31.22 cents a thousand cubic feet, the remaining 9 per cent being supplied to 676 industrial consumers at an average price of 19.95 cents a thousand. Compared with 1915 the average domestic rate was greater in 1916 by 0.03 cent and the industrial rate by 1 cent. The average volume of natural gas used by each domestic consumer in 1916 was 118,000 cubic feet, and the average monthly cost to him of natural-gas service was $3.06. The average volume of natural gas used by each industrial consumer was 2,617,000 cubic feet and his monthly bill averaged $43.50.

The deficiency between the volume of natural gas consumed in New York in 1916 and the volume produced in that State in the same year was supplied from the gas fields of northern Pennsylvania.

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Record of natural-gas industry in New York, 1898–1916.

Year.	Gas produced.		Gas consumed.			Wells.		
	Number of producers.	Value.	Number of consumers.		Value.	Drilled.		Productive Dec. 31.
			Domestic.	Industrial.		Gas.	Dry.	
1898	62	$229,078	a 68,662	103	$1,006,567	63	9	422
1899	84	294,593	a 76,544	121	1,236,007	36	7	447
1900	89	335,367	a 89,837	138	1,456,286	57	11	504
1901	114	293,232	a 95,161	98	1,694,925	53	14	557
1902	116	346,471	50,536	215	1,723,709	69	8	626
1903	144	493,686	57,935	208	1,944,667	75	11	700
1904	153	522,575	67,203	451	2,222,980	78	12	744
1905	148	623,251	67,848	447	2,434,894	89	17	839
1906	143	672,795	74,538	95	2,654,115	64	14	919
1907	208	766,157	83,805	155	3,098,533	61	13	1,049
1908	215	959,280	91,391	213	3,281,312	68	19	1,211
1909	282	1,222,666	92,958	570	3,286,523	86	18	1,340
1910	273	1,678,720	106,538	717	3,963,872	97	20	1,411
1911	302	1,418,767	116,314	208	4,276,324	167	53	1,531
1912	332	2,343,379	129,930	805	4,866,821	218	54	1,736
1913	366	2,425,633	136,830	639	4,888,412	200	54	1,929
1914	367	2,000,352	146,236	666	5,510,204	178	55	2,031
1915	346	2,335,252	153,972	815	5,676,097	176	50	2,046
1916	360	2,524,115	159,886	676	6,230,826	106	35	2,008

a Number of fires supplied.

Depth and rock pressure of wells in New York, 1912–1916.

County.	Depth (feet).	Pressure (pounds).				
		1912	1913	1914	1915	1916
Allegany	600–2,000	7– 300	7– 250	15–150	10–250	8–200
Cattaraugus	400–3,300	0– 700	0– 500	0–400	5–150	4–280
Chautauqua	150–3,250	0–a 900	0– 700	0–800	0–750	0–402
Erie	360–3,200	25–a 950	42–a 1,000	15–750	30–700	30–900
Niagara	550					
Genesee	1,150–1,905	500	400	450	500–600	500
Livingston	345–2,000	200– 525	200– 400	200–350	150–350	250–300
Monroe	440–1,400	50– 400	160– 400	160–205	220	210
Onondaga	1,000–3,000	3– 300	400– 600	300	150	
Ontario	114–2,400	55– 450	1– 450	3– 60	50–480	50–200
Seneca	1,250–1,550					
Oswego	700–1,700	8– 75	25– 145	3–300	10–200	25–500
Schuyler	1,000–1,800	300– 435	150– 435	3–435	5–300	
Yates	375–1,900					
Steuben	130–1,200	75– 200	75– 400	75–200	75–145	75–150
Wyoming	1,100–2,000	110– 140	140– 400	250–300	165–210	200

a New well.

PENNSYLVANIA.

GENERAL STATEMENT.

As a contributor to the volume of natural gas consumed annually in the United States, Pennsylvania has been an important factor since the earliest development of the natural-gas industry on a commercial scale. As early as 1872 waste gas from oil wells was utilized for light and fuel in Titusville, Crawford County, and in Karns City, Petrolia, Argyle, and Fairview, Butler County; and as early as 1873 it was employed as an industrial fuel in iron and steel plants near Pittsburgh. Between 1883, when gas from the Murrysville district, Westmoreland County, was first piped to Pittsburgh (and the natural-gas industry, as such, may be said to have really begun), and 1892, the value of the

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natural gas produced annually in Pennsylvania exceeded the combined value of the output from all the other gas-producing States, and until 1910 the value of Pennsylvania's annual output of natural gas was greater than that of any other State. In 1910 Pennsylvania was forced to yield first place, based on the market value of gas produced, to West Virginia, since which year it has retained second place without serious competition.

The natural-gas fields of Pennsylvania are essentially coincident with the oil fields of the State, though they extend a few miles in advance of the oil belt along its eastern boundary. They are distributed over 23 counties in the western and northwestern parts of the State and occupy the broad belt of gently folded strata that make up the Allegheny Plateau.

Natural gas in Pennsylvania is obtained commercially from a great number of productive sandstone layers included in the stratigraphic range between the Kane sand in the lower division of the Devonian system and the Hurry-up sand at the base of the Conemaugh formation of the Pennsylvanian (upper Carboniferous) series.

The principal gas-yielding sands in the State are as follows: Northwestern Pennsylvania—Kane, Elk (Waugh and Porter), Bradford, Cherry Grove, Speechley, Tiona, Warren second, Warren first, and Elizabeth, of the Devonian system; western Pennsylvania—Gordon, Bowlder, and Thirty-foot of the Devonian (?) system, and Fifty-foot, Gantz, and Berea (Butler County gas sand), of the Mississippian series; southwestern Pennsylvania—Fifth, Gordon, Bowlder, Thirty-foot, Fifty-foot, Gantz, Murrysville, Berea, and Big Injun sands of the Devonian system, and the Maxton sand and the Homewood and Mahoning sandstones of the lower part of the Carboniferous system. In Erie County shallow wells sunk in the dark carbonaceous shale in the upper part of the Devonian system yield small volumes of low-pressure gas, rarely more than enough to supply the domestic requirements of two or three households each.

PRODUCTION.

The estimated volume of natural gas produced in Pennsylvania in 1916 was 129,925,150,000 cubic feet, a gain of 16,223,460,000 cubic feet, or 14 per cent, over the output in 1915. In the history of the local industry this output is greater than that in any other year except 1912, when the production was in excess of 135,000,000,000 cubic feet. This gain in production was in direct response to enormously increased demands for natural gas in the iron and steel districts about Pittsburgh. It was accomplished by the discovery of no new fields of consequence, but by a large increase in drilling on reserve acreage in fields already proved.

The market value of the gas produced in Pennsylvania in 1916 was $24,344,324, a sum greater by $3,204,719, or 15 per cent, than that of the gas produced in 1915, and in fact appreciably greater than that of the gas produced in Pennsylvania in any preceding year.

The average price received in 1916 at the point of consumption for natural gas produced in Pennsylvania was 18.74 cents a thousand cubic feet, a gain of 0.15 cent, or slightly less than 1 per cent, over the average in 1915.

Field activity in the quest of natural gas in Pennsylvania in 1916 was decidedly greater than in any preceding year except 1913. In

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all 1,009 new wells were brought in during the year, a gain of 146 wells, or 17 per cent, over 1915. In addition to the supply of gas obtained from these wells, which furnished no other economic product, there was available for consumption in Pennsylvania in 1916 an augmented supply of natural gas obtained from wells that also produce petroleum. This type of gas, known as casing-head gas, or "wet" gas, contains appreciable quantities of gasoline vapor and has become in recent years, as shown by statistics in another section of this chapter, an important source of gasoline. The result of the steps taken to conserve this type of gas, which was formerly permitted to waste in large aggregate volume in Pennsylvania, is a material addition to the supply of natural gas available for domestic and industrial consumption within the State. The negligible loss in fuel value of this gas brought about by the removal of the gasoline vapors is more than offset by the improved service that the gas-distributing companies are able to render by reason of the drying effect on the gas of the removal of vapors that formerly condensed in large part in the distributing mains and caused annoying interruptions of service, particularly in cold weather.

Operators in practically all the gas fields in Pennsylvania report a steady decline in 1916 in both the volume and rock pressure of gas obtained in old wells, and many report the failure of new gas wells to compare favorably in initial yield and pressure or in lasting qualities with those drilled a decade ago.

At the end of 1916 there were 13,917 gas wells in service in Pennsylvania, exclusive of a great number of other wells that produce both gas and oil.

Although the volume of natural gas produced in Pennsylvania in 1916 was insufficient for the needs of gas consumers in that State, a volume estimated at 14,793,746,000 cubic feet, valued at $4,329,168, was piped from the State to supply consumers in New York, Ohio, and West Virginia.

CONSUMPTION.

Although Pennsylvania has been forced in recent years to accept second rank as a producer of natural gas, its claim to first place as a consumer of this fuel is still undisputed. The volume of natural gas required annually for the operation of the blast furnaces, foundries, and rolling mills of the iron and steel industry and the manufacturing plants of a score of other industries centered in the Pittsburgh district alone is more than double the volume required to supply the needs of nearly half a million domestic consumers of natural gas in the same State, and in each of the last six years it has exceeded the total volume of gas produced in the State by several billion cubic feet.

The estimated volume of natural gas consumed in Pennsylvania in 1916 was 201,460,893,000 cubic feet, a gain of 25,093,658,000 cubic feet, or 12 per cent, over 1915.

The market value of this gas at the point of consumption was $35,015,695, a gain of $4,928,028, or 14 per cent, over 1915, which is accounted for in part by the increased volume of gas distributed and in part by an increase of 0.32 cent, or about 2 per cent, in the average retail price of the gas, the increase being from 17.06 cents a thousand in 1915 to 17.38 cents in 1916.

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Of the total volume consumed in 1916 about 55,605,995,000 cubic feet, or 28 per cent valued at $15,159,479, or 43 per cent of the total market value of all gas consumed in the State, was supplied to 463,264 domestic consumers at an average price of 27.26 cents a thousand. Compared with corresponding figures for 1915 these data show in 1916 a gain of 8 per cent both in the volume of gas consumed for domestic purposes and its total market value, and of 5 per cent in the number of consumers, but a decrease of 0.02 cent in the average price per thousand paid for natural gas service by the consumer in Pennsylvania. The volume of gas required monthly by the average domestic consumer in this State in 1916 was about 10,000 cubic feet and his monthly bill for fuel and light averaged about $2.73. The remaining 72 per cent of the gas consumed in Pennsylvania, representing 57 per cent of the market value of all gas consumed in the State, was supplied to 4,676 industrial consumers at an average price of 13.61 cents a thousand cubic feet. Compared with corresponding data for 1915, statistics relating to the consumption of natural gas for industrial purposes in Pennsylvania in 1916 show a gain of 17 per cent in the volume of gas involved, of 23 per cent in its total value, of 0.75 cent, or 6 per cent, in its average retail price per thousand, but a loss of 0.4 per cent in the number of consumers.

A further analysis of the statistics relating to industrial consumption of natural gas in 1916 shows that 90 per cent of the gas consumed was utilized directly as a source of heat in manufacturing plants and that only 10 per cent was consumed in the generation of power, either directly as in gas engines, or indirectly under boilers.

Of the total volume of natural gas consumed in Pennsylvania in 1916 it is estimated that 86,329,489,000 cubic feet, valued at $15,000,539, was piped into the State from West Virginia and New York, receipts from the latter State representing but a small part of the total.

Record of natural-gas industry in Pennsylvania, 1898–1916.

Year.	Gas produced.		Gas consumed.			Wells.		
	Number of producers.	Value.	Number of consumers.		Value.	Drilled.		Productive Dec. 31.
			Domestic.	Industrial.		Gas.	Dry.	
1898	232	$6,806,742	[a] 213,410	1,021	$6,064,477	373	74	2,840
1899	281	8,337,210	[a] 232,060	1,236	7,926,970	467	104	3,303
1900	266	10,215,412	[a] 229,730	1,296	9,812,615	513	142	3,776
1901	296	12,688,161	[a] 326,912	1,743	11,785,996	660	143	4,436
1902	379	14,352,183	185,678	2,448	13,942,783	775	232	5,211
1903	414	16,182,834	214,432	2,834	16,060,196	699	126	5,910
1904	414	18,139,914	238,481	2,929	17,205,804	701	174	6,352
1905	351	19,197,336	257,416	2,845	19,237,218	765	168	6,566
1906	309	18,558,245	273,184	3,307	21,085,077	603	153	7,300
1907	344	18,844,156	295,115	3,812	22,917,547	769	180	8,051
1908	[b] 572	19,104,944	307,585	4,577	20,678,161	571	147	[c] 8,831
1909	[b] 777	20,475,307	294,781	5,377	21,639,102	756	166	[c] 9,499
1910	[b] 819	21,057,211	321,430	4,102	23,934,091	857	161	[c] 10,337
1911	[b] 1,067	18,520,796	330,537	4,597	23,940,001	832	224	[c] 10,885
1912	[b] 1,104	18,539,672	345,765	3,442	26,486,302	993	219	[c] 11,543
1913	[b] 1,174	21,695,845	400,823	4,373	28,709,565	1,011	259	[c] 12,438
1914	[b] 1,325	20,839,869	415,644	4,307	28,439,324	998	236	[c] 13,073
1915	[b] 1,396	21,139,605	440,673	4,698	30,087,667	863	188	[c] 13,431
1916	[b] 1,586	24,344,324	463,264	4,676	35,015,695	1,009	252	[c] 13,917

[a] Number of fires supplied.

[b] Includes 216 producers having shallow wells in Erie County for their own domestic consumption in 1908, 311 producers in 1909, 345 producers in 1910, 399 in 1911, and 401 in 1912, 1913, 1914, 1915, and 1916.

[c] Includes 350 shallow wells in Erie County in 1908, 429 in 1909 and 1910, 476 in 1911, and 492 in 1912, 1913, 1914, and 1915, and 483 in 1916.

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Depth and rock pressure of wells in Pennsylvania, 1912–1916.

County.	Depth (feet).	Pressure (pounds).				
		1912	1913	1914	1915	1916
Allegheny	750–3,500	10– 500	15–a1,000	10– 700	10– 900	10– 700
Armstrong	575–3,600	5– 900	1– 500	1– 800	3– 500	3– 700
Beaver	700–2,000	30– 70	30– 510	40– 560	30– 200	10– 125
Butler	700–3,384	2– 700	4– 850	8– 450	8– a600	5–a800
Clarion	506–3,100	1– 900	2– 800	0– 700	2– a850	10– 700
Elk	500–3,200	60– 840	50– a980	60–a1,000	60– a900	50– 800
Crawford	550–1,200	2– 100	10– 50	5– 40	25– 30	.....
Erie	300–1,600					
Fayette	1,200–2,772	35– 700	35– 700	35– 550	600	400– 570
Cambria	2,350–2,500					
Forest	370–3,165	5– 800	17– 700	25– 600	3– 700	21–a900
Greene	680–3,600	60– 575	30– 750	50– 650	30– 500	30–a700
Indiana	1,100–1,880	.....	600	500	300	.....
Jefferson	700–3,360	90–1,000	100– 960	15–a1,100	5– 800	10– 740
McKean	750–3,000	1– 950	3– 800	2– 525	7– 900	4–a800
Mercer	800–1,150	190	51– 300	26– 450	150– 450	230– 280
Lawrence	650– 850					
Potter	750–2,400	10– 360	20– 600	50– 385	20– 300	70– 250
Tioga	700–1,400	.....	.....	.....	.....	.....
Venango	350–2,700	15– 200	10– 200	24– 450	15– 400	10– 600
Warren	500–3,290	10– 350	5– 280	5– 300	8– 80	0– 300
Washington	606–3,500	5– 550	5– 400	5– 400	2– 400	10– 500
Westmoreland	1,200–3,800	15– 20	6–a1,000	15–a1,000	1–a1,000	3–a900

a New well.

WEST VIRGINIA.

GENERAL STATEMENT.

The year 1916 was the eighth consecutive year in which West Virginia has led the gas-producing States of this country in the volume of natural gas produced and the seventh in which it has led in the value of such production.

Natural gas has been utilized in West Virginia since 1841, when it was adopted as a fuel for evaporating brine in the salt industry that was then centered in the Great Kanawha Valley, near Charleston. As early as 1884 natural gas was supplied to domestic and industrial consumers in Wellsburg, Brooke County, but it was not until the nineties that the natural gas industry in this State became important. Since 1896 the value of the annual production of natural gas in West Virginia has shown a steady increase, doubling once in 1898, again in 1900, again in 1903, and again in 1916. Since 1906, the first year in which an estimate of the volume of natural gas produced in West Virginia is available, the volume of the annual production has more than doubled, and its value has considerably more than trebled. The volume of natural gas piped from West Virginia for consumption in other States in 1916 was greater by 78,000,000,000 cubic feet than the entire volume produced in that State in 1906.

The natural-gas fields of West Virginia are distributed over 32 counties of the State and lie west of the Appalachian Mountains in the maturely dissected Allegheny Plateau province. In this State natural gas is found more abundantly than in Pennsylvania, not only as "wet" gas in association with petroleum, but as "dry" gas accumulated under favorable conditions in the sandstone or limestone reservoirs that yield no oil. The gas fields of the State are broadly coincident with the oil fields, but, as in Pennsylvania, the eastern

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boundary of the gas belt lies a few miles in advance of the eastern limits of oil production.

Stratigraphically the oil and gas bearing rocks of West Virginia range in position from the base of the Catskill (?) formation in the upper part of the Devonian system to the lower part of the Monongahela formation of the Pennsylvanian series, production being found in a great number of sandstone layers, and one limestone layer (Greenbrier limestone or Big lime), between the Elizabeth or Seventh sand at the base and the Carroll sand or Uniontown sandstone member at the top. Of these the principal sources of natural gas are, in descending order, the Gas (Second Cow Run), Salt, Maxton, Big lime, Big Injun, Berea, and Gordon sands.

PRODUCTION.

The volume of natural gas produced commercially in West Virginia in 1916 establishes a new record of gas production for the State. This volume is estimated to have amounted to 299,318,907,000 cubic feet, a gain of 55,314,748,000 cubic feet, or 18 per cent, over the output in 1915, and of nearly 54,000,000,000 cubic feet over the previous record of production set in 1913.

The market value of the output in 1916 is placed at $47,603,396, a gain of $11,179,133, or 23 per cent, over that of the output in 1915, and of $13,438,546, or 28 per cent, over that of the output in 1913. The gain in 1916 is due in part to the 18 per cent gain in the volume of gas produced and in part to an advance of 0.97 cent in the average selling price per thousand of the gas, this average in 1916 being 15.90 cents, compared with 14.93 cents in 1915, and 13.92 cents in 1913.

As might be expected from the statistics of production, the year 1916 was one of unusual activity in drilling for natural gas in West Virginia. In all, 1,055 gas wells were completed in this State in that year, this number being greater by 276 wells, or 35 per cent, than the number completed in 1915, and greater by 17 wells, or nearly 2 per cent, than the number completed in 1913, the year of greatest previous activity. Exclusive of the great number of wells that produce both gas and oil in West Virginia, there were in this State at the end of 1916 a total of 8,508 wells that produced gas exclusively, this number showing a net gain of 790 wells, or 10 per cent, over 1915. In drilling for natural gas in West Virginia in 1916 a total of 161 barren wells were completed, the ratio of dry holes to productive wells drilled being as 2 to 13.

The gain in natural-gas production in West Virginia in 1916 is accounted for principally by the increased number of gas wells brought in during the year, though increased activity in drilling for petroleum resulting from an advancing market for that commodity and increased conservation of casing-head gas from oil wells, both old and new, resulting from a wider appreciation of the value of such gas for the manufacture of gasoline, added materially to the total. In addition to supplying the greater part of its own requirements of natural gas in 1916, West Virginia supplied a volume of gas estimated at 197,562,696,000 cubic feet, of a market value of $39,680,996, to consumers in Pennsylvania, Ohio, Indiana, Kentucky, and Maryland.

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CONSUMPTION.

Although first in the production of natural gas, West Virginia attains no higher than fourth in rank among the States in which natural gas is consumed. Inclusive of that consumed in a few towns in Maryland adjacent to the West Virginia boundary, the volume of natural gas consumed in West Virginia in 1916 is estimated at 105,104,008,000 cubic feet, or about 35 per cent of the total volume produced in the State. This volume, however, is 10,127,303,000 cubic feet, or 11 per cent, greater than the volume consumed locally in 1915, though it represents 4 per cent less of the total volume of gas produced in the State than did the volume consumed locally in 1915.

The average price paid by all consumers of natural gas in this State in 1916 was 8.19 cents a thousand cubic feet, a gain of 0.34 cent compared with the average rate in 1915. As a consequence of this slight gain and of the larger volume of gas consumed, the market value of the entire consumption, which was $8,610,084, was greater by $1,159,081, or 15 per cent, than that of the gas consumed in 1915.

Of the total volume of gas consumed in 1916, about 18,779,871,000 cubic feet, or 18 per cent, valued at $3,389,400, representing 39 per cent of the market value of all gas consumed locally, was distributed to 123,860 domestic consumers at an average price of 18.05 cents a thousand cubic feet. A comparison of these data with corresponding items relating to the consumption of natural gas in West Virginia in 1915 shows increase of 5 per cent in volume and of 7 per cent in the number of consumers benefited, but of only 3 per cent in the total market value of the gas consumed for domestic purposes, because of a decrease of 0.29 cent in the average price per thousand paid for natural-gas service.

The average monthly consumption of each domestic consumer provided with natural-gas service in West Virginia in 1916 was 12,700 cubic feet, which was supplied to him at an average monthly cost of only $2.30.

The remaining 82 per cent of the gas consumed in West Virginia in 1916, representing 61 per cent of the market value of the entire consumption, was distributed to 1,963 industrial consumers at an average price of 6.05 cents a thousand. Compared with 1915 these data show gain of 12 per cent in volume, of 3 per cent in the number of consumers, and of 25 per cent in the market value of the gas consumed, due in part to the larger volume and in part to an increase of 0.64 cent, or 12 per cent, in the average price paid for natural gas for industrial use.

One of the chief consumers of industrial gas in West Virginia is the carbon black industry, for the success of which a large supply of gas that can be obtained at a low price is necessary. Natural gas was first used commercially as a source of carbon black in 1864, the plant in which it was first used for this purpose being at New Cumberland, Hancock County. The success of this plant and the increasing evidence of an abundant supply of natural gas in West Virginia led to the gradual development of an important industry that in recent years has required more gas annually than has been supplied to domestic consumers within the State. It is estimated that 23,468,892,000 cubic feet of natural gas, valued at $568,742, an average of 2.42 cents a thousand, was consumed at carbon black factories in West Virginia

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in 1916. From the burning of this volume of gas it is estimated that 22,818,943 pounds of carbon black was manufactured.

Of the total volume of natural gas consumed in West Virginia in 1916, a small proportion was piped into the State from Pennsylvania and Ohio as a matter of convenience to supply consumers adjacent to the State boundaries.

Record of natural-gas industry in West Virginia, 1898–1916.

Year.	Gas produced.		Gas consumed.			Wells.		
	Number of producers.	Value.	Number of consumers.		Value.	Drilled.		Productive Dec. 31.
			Domestic.	Industrial.		Gas.	Dry.	
1898	19	$1,334,023	[a] 28,652	125	$914,969	32	4	227
1899	30	2,335,864	[a] 28,137	305	1,310,675	78	6	300
1900	34	2,959,032	[a] 45,943	184	1,530,378	129	6	428
1901	44	3,954,472	[a] 55,808	266	2,244,758	177	8	604
1902	79	5,390,181	29,357	877	2,473,174	142	37	745
1903	88	6,832,359	36,179	1,122	3,125,061	242	43	987
1904	90	8,114,249	44,563	1,005	3,383,515	292	33	1,274
1905	76	10,075,804	45,588	1,417	3,586,608	385	28	1,579
1906	67	13,735,343	51,281	913	3,720,440	263	23	1,831
1907	105	16,670,962	53,807	1,000	[b] 3,757,977	377	59	2,169
1908	138	14,837,130	63,228	1,225	[b] 4,020,282	441	80	2,511
1909	183	17,538,565	70,853	1,907	[b] 5,183,054	801	65	3,232
1910	241	23,816,553	86,778	2,659	[b] 5,617,910	1,002	69	4,052
1911	340	28,435,907	87,438	1,566	[b] 6,240,152	905	117	4,790
1912	406	33,324,475	94,273	1,953	[b] 7,001,331	870	149	5,533
1913	451	34,164,850	101,234	1,834	[b] 7,333,956	1,038	128	6,534
1914	475	35,076,755	108,277	1,850	[b] 7,334,690	856	154	7,194
1915	506	36,424,263	115,908	1,910	[b] 7,451,003	779	97	7,718
1916	544	47,603,396	123,860	1,963	[b] 8,610,084	1,055	161	8,508

[a] Number of fires supplied. [b] Includes gas consumed in Maryland.

Depth and rock pressure of wells in West Virginia, 1912–1916.

County.	Depth (feet).	Pressure (pounds).									
		1912		1913		1914		1915		1916	
Boone	1,060–3,900	350–	520	400–	525	130–	550	200–	600		435
Braxton	1,200–3,000						400		800		550–650
Clay	1,400–2,800	300–	600	200–	450	300–	500	250–	400		100–420
Taylor	1,453–2,800	100–	600	400–	1,000	110–	800	135–	800		250–450
Brooke	1,200–1,950	0–	270	0–	640	0–	180	0–	80		0–150
Cabell	900–2,800	350–	400	350–	500		400		400		
Calhoun	824–4,000	20–	760	60–	400	10–	[a] 1,200	20–	650		50–540
Doddridge	1,400–3,100	5–	700	75–	900	50–	465	50–	400		25–400
Gilmer	1,148–3,181	130–	210	100–	180	100–	600	112–	700		160–650
Hancock	700–1,880	20–	150	40–	100	20–	75		30		75
Harrison	700–4,500	40–	900	50–	900	100–	900	70–	800		30–850
Kanawha	715–2,585	250–	600	50–	500	225–	500	210–	480		90–490
Lewis	1,127–3,000	45–	[a] 1,100	50–	[a] 1,100	20–	[a] 1,000	80–	[a] 900		85–800
Lincoln	900–2,720	200–	600	400–	560	300–	540	220–	500		250–550
Logan	1,122–2,200	550–	560	75–	540	75–	540	400–	450		300
Marion	1,280–3,478	75–	805	40–	500	75–	600	30–	[a] 925		15–500
Marshall	1,000–3,500	6–	300	125–	300	110–	300	110–	150		60–200
Mingo	1,600–2,600	375–	550	250–	600	200–	500	425–	580		50–550
Wayne	1,300–2,000										
Monongalia	1,250–3,500	60–	825	60–	820	60–	800	37–	725		30–300
Nicholas	1,200–1,300	15–	350	25–	350	15–	350	15–	525		20
Ohio	550–2,000										
Pocahontas	2,000–2,500										
Pleasants	900–2,150	50–	300	30–	500	30–	250	125–	375		30–400
Putnam	900–2,400										
Upshur	1,928–2,800	480–	600		460	350–	360		240		100
Ritchie	600–3,000	20–	700	30–	700	20–	600	20–	500		20–730
Roane	1,450–2,700	320–	465	350–	750	240–	600	175–	500		200–400
Tyler	1,400–3,400	50–	750	50–	650	150–	685	10–	500		25–450
Wetzel	1,000–3,560	50–	113	5–	150	5–	150	50–	130		50–600
Wirt	500–1,875	30–	500	18–	275	70–	125	30–	150		30–100
Wood	1,030–1,900	300–	520	150–	500	198–	400	40–	460		200–400

[a] New well.

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OHIO.

GENERAL STATEMENT.

Despite a decline of 12 per cent in the volume of natural gas produced commercially in Ohio in 1916, this State easily maintained its rank of fourth among the gas-producing States.

Natural gas has been in use in Ohio since 1838, when it was employed as fuel in the residence of Daniel Foster in Findlay, Hancock County, the supply being derived from a well drilled for water. As early as 1860 oil-field gas was used in the manufacture of salt at East Liverpool, Columbiana County, but it was not until the early seventies that the drilling of wells specifically for gas was undertaken in Ohio. As an industry apart from the petroleum industry the natural-gas industry of Ohio was unimportant until the discovery of the great reservoirs of this fuel in the "Trenton" limestone, in Hancock County, in 1884–1886. In the decade 1885–1894 the value of the natural gas produced annually in Ohio increased from $100,000 to more than $1,000,000, and in the succeeding 10 years to more than $5,000,000. Since 1904 it has been in excess of $5,000,000 annually, and since 1911 it has been in excess of $10,000,000.

The natural-gas fields of Ohio are distributed over some 50 counties lying in the eastern half and the northwestern quarter of the State. The principal field, generally referred to as the central Ohio gas belt, is a little east of the central part of the State and extends from Vinton County on the south to Lake Erie on the north, the continuity of the field being broken by unproductive areas in southern Hocking, central Fairfield, southern Ashland, central Medina, and southern Cuyahoga counties.

In northeastern Ohio gas in small volume is obtained in shallow wells sunk in the black Ohio shale of the Devonian system, the yield of individual wells being rarely more than sufficient for the fuel needs of more than two families. Outside the central gas belt and the shale gas area the natural gas produced in Ohio is for the most part obtained from wells that also yield petroleum.

In southeastern Ohio natural gas is obtained from a number of productive sands in the succession of rocks between the Berea sandstone at the base of the Mississippian series, and the Goose Run sand, in the upper part of the Monongahela formation of the Pennsylvanian series. In the central gas belt production is obtained chiefly from the Clinton sand of the Silurian system. In the northwestern part of the State the principal source of natural gas is the "Trenton" limestone of the Ordovician system.

PRODUCTION.

It is estimated that the volume of natural gas produced in Ohio in 1916 was 69,888,070,000 cubic feet, a decline of 9,621,962,000 cubic feet, or 12 per cent, from 1915. The average price received for this gas at the point of consumption was 22.32 cents a thousand, and the market value of the entire output was $15,601,144, this sum being less by $1,789,916, or only 10 per cent, than the value of the output in 1915, because of an increase of 0.45 cent in the average selling price per thousand in 1916.

The diminished output of natural gas in Ohio in 1916 is accounted for chiefly by the rapid exhaustion of the prolific Cleveland gas field in

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Cuyahoga County that came into prominence in 1914 and contributed nearly 40 per cent of the gas produced in the entire State in 1915.

As a result of the close spacing of wells and the consequent rapid exhaustion of this field, the contribution of Cuyahoga County to the entire output of gas in Ohio in 1916 was considerably less than in 1915.

In all 593 gas wells were completed in Ohio in 1916, a loss of 207 wells, or 26 per cent, from 1915. No strictly new gas fields were discovered in Ohio in 1916, though moderate extensions of producing territory were proved in a number of localities in the central gas belt, particularly at its southern end in the northern part of Vinton County.

Inclusive of the shale gas wells, but exclusive of the oil wells that contribute to the gas supply in Ohio, it is estimated that 6,054 gas wells were in service in Ohio at the end of 1916, a net loss of 10 wells during the year.

CONSUMPTION.

Although fourth in rank as a producer of natural gas, Ohio is second in rank as a consumer of this fuel. It is estimated that the volume of natural gas consumed in Ohio in 1916 was 169,480,011,000 cubic feet, a gain of 22,755,022,000 cubic feet, or 15.5 per cent, over 1915. The value of this gas at the point of consumption was $37,394,410, a gain of $5,493,646, or 17 per cent, over 1915, which was due in part to the increased volume and in part to an increase of 0.32 cent in the average price per thousand at which the gas was sold.

Of the total volume of gas consumed in Ohio in 1916, about 84,657,622,000 cubic feet, or 50 per cent, valued at $25,208,751, or 67 per cent of the total value of the gas consumed, was distributed to 836,828 domestic consumers at an average price of 29.78 cents a thousand cubic feet. Compared with corresponding statistics for 1915 these data record gain of 10 per cent in the volume of gas consumed, of 8 per cent in the number of domestic consumers, and of 11 per cent in the market value of gas consumed, but of only 1.4 per cent in the average price per thousand paid by the consumers benefited.

The average volume of gas used monthly by each domestic consumer of natural gas in Ohio in 1916 was 8,500 cubic feet, obtained at an average monthly cost of $2.53.

The remaining 50 per cent of the volume of gas consumed in Ohio in 1916, representing only 33 per cent of the total value of the gas consumed in the State in that year, was supplied to 4,602 industrial consumers at an average price of 14.37 cents a thousand. Compared with 1915 these data show gain in 1916 of 22 per cent in the volume of gas consumed for industrial purposes, of 17 per cent in the number of consumers, of 31 per cent in the market value of the gas consumed, and of 1.05 cents, or 8 per cent, in the average price per thousand paid for industrial gas.

The diminishing supply of natural gas in Ohio and the increasing demand for it for domestic uses resulted late in 1916 both in the curtailment and, in some places, in the termination of deliveries by distributing companies of natural gas for industrial consumption in a number of cities and towns in eastern Ohio. This action, which

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caused an increase in the demand for coal in the areas where it became effective, is abundantly justified by the principles of true conservation, which require that natural resources shall be devoted to their highest uses and so exploited as to bring the greatest good to the greatest number. That the application of these principles in the natural-gas industry involves the distribution of this ideal fuel to as many individual homes as possible there is normally no question. Only in time of war, when the success or failure of an essential war industry is involved, can it be conceived that industrial consumers might have, in the interests of public welfare, a more equitable claim to a limited supply of natural gas than domestic consumers.

In addition to consuming practically all the gas produced within the State in 1916, it is estimated that consumers in Ohio utilized 100,257,443,000 cubic feet of gas piped from West Virginia, Pennsylvania, and Indiana.

Record of natural-gas industry in Ohio, 1898–1916.

Year.	Gas produced.		Gas consumed.			Wells.		
	Number of producers.	Value.	Number of consumers.		Value.	Drilled.		Productive Dec. 31.
			Domestic.	Industrial.		Gas.	Dry.	
1898	237	$1,488,308	[a] 68,211	349	$2,250,706	120	12	806
1899	359	1,866,271	[a] 77,787	691	3,207,286	134	17	929
1900	281	2,178,234	[a] 135,743	1,092	3,823,209	97	19	990
1901	305	2,147,215	[a] 149,709	949	4,119,059	113	35	1,099
1902	451	2,355,458	120,127	786	4,785,766	266	40	1,343
1903	515	4,479,040	197,710	1,786	7,200,867	290	62	1,523
1904	453	5,315,564	232,557	1,136	9,393,843	334	49	1,661
1905	425	5,721,462	274,585	2,955	10,396,633	342	58	1,705
1906	409	7,145,809	310,175	3,316	12,652,520	337	51	[b] 1,977
1907	468	8,718,562	380,489	5,476	15,227,780	431	90	2,942
1908	[c] 970	8,244,835	427,276	3,621	15,166,434	398	124	[d] 3,691
1909	[c] 1,534	9,966,038	450,073	5,260	18,884,312	548	149	[d] 4,260
1910	[c] 1,630	8,626,854	475,505	3,187	21,210,965	466	202	[d] 4,717
1911	[c] 1,900	9,367,347	577,253	3,634	22,792,370	450	191	[d] 4,999
1912	[c] 2,031	11,891,299	641,724	4,414	27,196,162	637	289	[d] 5,163
1913	[c] 2,056	10,521,930	685,956	5,010	27,055,824	408	235	[d] 5,308
1914	[c] 2,268	14,667,790	734,354	6,102	29,936,642	686	257	[d] 5,809
1915	[c] 2,499	17,391,080	773,548	5,621	31,900,764	800	260	[d] 6,064
1916	[c] 2,503	15,601,144	836,828	4,602	37,394,410	593	204	[d] 6,054

[a] Number of fires supplied.
[b] Exclusive of complete report of shallow wells.
[c] Includes 735 producers in Ashtabula, Erie, Huron, Lake, Lorain, and Cuyahoga counties having shallow wells for their own domestic purposes in 1908, 1,239 in 1909, 1,289 in 1910, 1,476 in 1911, 1,579 in 1912, 1,600 in 1913, and 1,561 in 1914, 1915, and 1916.
[d] Includes 901 shallow wells located in Ashtabula, Erie, Huron, Lake, Lorain, and Cuyahoga counties in 1908, 1,568 in 1909, 1,541 in 1910, 1,757 in 1911, 1,773 in 1912, 1,778 in 1913, and 1,733 in 1914, 1915, and 1916.

Depth and rock pressure of wells in Ohio, 1912–1916.

County.	Depth (feet).	Pressure (pounds).									
		1912		1913		1914		1915		1916	
Allen	1,200–1,470										
Ashland	2,400–3,000	250–	650	90–	500	105–	300	80–	500	75–	400
Ashtabula	400–2,200	0–	410			30–	250	20–	[a] 670	20–	740
Athens	440–1,500	10–	350	50–	350	10–	170	30–	170	20–	150
Auglaize	1,100–1,300	5–	110	3–	140	7–	70	5–		1–	5
Belmont	778–2,200	20–	50	60–	140		125	110–	125	100–	600
Carroll	500–1,434	100–	150	90–	150						
Clermont	500– 513										
Clinton	715–		160		95		100		90		60

[a] New well.

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Depth and rock pressure of wells in Ohio, 1912–1916—Continued.

County.	Depth (feet).	Pressure (pounds).				
		1912	1913	1914	1915	1916
Columbiana	500–2,000	25– 350	16– 300	16– 350	25– 300	12– 325
Cuyahoga	337–3,200	0– a 800	0–a1,000	0–a1,200	0–a1,100	0– 750
Darke	750–1,500	2– 300	2– 200	2– 250	2– 300	0– 300
Erie	350– 650	18– 40				
Fairfield	213–2,800	40– 350	16– 320	25– 325	25– 150	15– 400
Fulton	80– 150					0– 30
Guernsey	700–1,500	250	300	300	30– 400	25– 400
Muskingum	800–3,350					
Hancock	800–1,800	2– 400	2– 150	1– 200	1– a 400	0– 300
Hardin	1,200–1,800	75– 300	20– 300	20– 350	15– 425	10– 425
Harrison	400–1,650	10– 150	5– 225	8– 300	18– 200	2– 190
Hocking	750–3,300			430	300	240
Huron	400– 800	0– 40				
Holmes	600–1,160	100– 170	80– 165	80– 165	80– 180	80– 260
Jefferson	600–2,026	12– a 890	15– 300	20– 250	15– 150	40– 200
Knox	590–3,500	15– 250	50– 300	75– 250	75– 300	75– 900
Lake	360–1,700	0– 185				
Lawrence	1,600–1,834		750	425	500– 600	
Licking	1,950–3,000	80– 400	30– 450	30– a 600	40– a 625	45– 625
Logan	1,234–1,500	20– 180	160	30– 120	125– 200	50– 150
Lorain	338–2,590	0– a 900	0– 675	0– 150	0– 54	
Lucas	700–1,550	7– 30	9– 30	5– 39	8– 35	18
Mahoning	500–2,000	a 160	150– 158	70– 187	85– 187	80– 160
Medina	175–3,000	4–a1,100	2– 500	3– 300	2– 50	2– 20
Meigs	600–2,000					0– 115
Mercer	1,000–1,400	1– 100	1– 105	5– 75	4– 180	4– 100
Monroe	650–2,400	8– 200	3– 100	20– 350	20– 160	474– 400
Morgan	240–1,650	20– 450	15– 450	20– 350	40– 500	40– a 570
Noble	484–2,000	100– 620	150– 620	40– 380	40– 450	50– 500
Ottawa	1,200–2,000	40– 450	30– 350	125– 350	30– 450	100– 200
Perry	650–3,620	150– 800	150– 600	50– 80		200
Richland	1,950–2,800	200– 250				80
Sandusky	400–1,451	5– 160	5– 150	10– 160	1– 150	2– 150
Sciota	1,535					
Seneca	370–1,760	20– 110	20– 140	20– 100	70– 90	25– 165
Summit	900–3,550	a 980– 1,020				
Trumbull	370– 388		10	10		
Tuscarawas	850–5,050	180– 350	160– 475	120	78– 400	70– 800
Van Wert	1,200–1,285	40				
Vinton and Jackson	520–2,707					810
Warren	275–1,000					
Wayne	1,150–3,500	a 800	300–a1,120	200– 850	100– a 900	100–a1,000
Washington	500–2,600	15– 600	15– 500	10– 740	15– 400	30– 400
Wood	1,170–1,500	10– 12	10– 15	10– 35	10– 40	10– 40

a New well.

KENTUCKY.

GENERAL STATEMENT.

The production of natural gas in Kentucky, though important locally, amounts to less than 1 per cent of the total volume produced annually in the United States. The first well drilled in Kentucky that produced natural gas in considerable volume was the Moreman well, drilled in 1863 on the Moreman farm, near Brandenburg, Meade County, not far from the Ohio line. In 1872 gas from this well was utilized in the Moreman salt works for the manufacture of salt from the brine that was associated with the gas in this and other wells in the Brandenburg district. With the discoveries of gas in Ohio and Indiana in 1885 and 1886, interest in the quest for natural gas in Kentucky was greatly stimulated, with the result that the Brandenburg district was considerably extended and a sufficient volume of gas was developed to warrant the laying in 1888 of an 8-inch main to Louisville, 30 miles distant. Since 1889 Kentucky has been a regular though small contributor to the gas supply of the United

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States, the value of its annual contribution attaining a maximum in excess of $750,000 in 1916.

The natural-gas fields of Kentucky, as now developed, are widely distributed but lie mainly in the eastern third of the State. The principal producing district is the Menifee gas field in Menifee County, where the gas produced is obtained from the "Corniferous" limestone of the Devonian system. In Morgan and Wolfe counties gas is produced commercially from oil wells tapping the same formation that yields gas in Menifee County. In Martin County gas is produced from the Big Injun sand of the Mississippian series. In the oil fields of Wayne and McCreary counties gas is obtained from the Beaver Creek "sand," a layer of cherty limestone near the base of the "Waverly" formation of the Mississippian series. In Knox County gas is obtained from impersistent sands in the Pottsville group of the Pennsylvanian series and in the upper part of the "Waverly" formation of the Mississippian series. In Estill County more or less gas accompanies the oil in the Irvine field, production being obtained from the "Corniferous" limestone of the Devonian system. In the western part of the State gas in small volume is found in shallow wells sunk in the black New Albany shale of the Devonian system, this formation being the source of the gas obtained in Meade County, where the natural-gas industry in Kentucky originated.

PRODUCTION.

The volume of natural gas produced commercially in Kentucky in 1916 was about 2,106,542,000 cubic feet, an increase of 439,119,000 cubic feet, or 26 per cent, over the output in 1915.

Increased activity in the oil fields of Kentucky resulting in a greater demand for natural gas for drilling purposes and increased conservation of oil-field gas resulting from a greater appreciation of the value of this type of gas for the manufacture of gasoline account largely for the gain in natural-gas production in this State in 1916.

The value of this gas at the point of consumption was $752,635, a gain of $137,737, or 22 per cent, over the value of the output in 1915. Because of a larger relative distribution of Kentucky gas for industrial and field purposes in 1916 than in 1915 the average price per thousand received for the output in 1916 declined from 36.88 cents to 35.73 cents, a loss of 1.15 cents, or 3 per cent.

Activity in drilling for gas in Kentucky in 1916 resulted in the completion of 20 new wells, 13 of which were successful. Exclusive of the wells that also produce oil, there were 266 gas wells in service in Kentucky at the end of 1916, a net gain of 4 wells during the year.

CONSUMPTION.

The volume of natural gas consumed in Kentucky in 1916 is estimated at 9,887,956,000 cubic feet, a gain of 2,141,603,000 cubic feet, or 28 per cent, over the volume consumed in 1915. The discrepancy between the volume of gas produced in Kentucky and that consumed in this State was made up by importations from West Virginia and Ohio, the greater part being obtained from West Virginia.

Of the total volume of natural gas consumed in Kentucky in 1916 it is estimated that 5,860,235,000 cubic feet, or 59 per cent, valued

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at $1,965,892, or 84 per cent of the total market value of gas consumed, was supplied to 85,583 domestic consumers at an average price of 33.55 cents a thousand. A comparison of these statistics with data relating to domestic consumption of natural gas in Kentucky in 1915 shows gain in 1916 of 19 per cent in volume, of 17 per cent in total market value, and of 11 per cent in the number of consumers, but decrease of 0.54 cent, or nearly 2 per cent, in the average price per thousand paid by domestic consumers.

The average volume of gas consumed monthly by each domestic consumer of natural gas in Kentucky in 1916 was 5,700 cubic feet, obtained at an average monthly cost of $1.91.

The remaining 41 per cent of the gas consumed in Kentucky in 1916, representing 16 per cent of the market value of the entire consumption, was supplied to 125 industrial consumers at an average price of 9.08 cents a thousand. A comparison of the statistics of these factors in 1915 and 1916 shows gain in 1916 of 42 per cent in volume, of 41 per cent in market value, of 7 per cent in the number of consumers, but decrease of 0.1 cent, or 1 per cent, in the average price per thousand paid for industrial gas.

Record of natural-gas industry in Kentucky, 1906–1916.

Year.	Gas produced.		Gas consumed.			Wells.		
	Number of producers.	Value.	Number of consumers.		Value.	Drilled.		Productive Dec. 31.
			Domestic.	Industrial.		Gas.	Dry.	
1906	45	$287,501	17,216	18	$287,501	.....	.....	166
1907	38	380,176	19,279	239	380,176	31	14	179
1908	38	424,271	21,778	42	424,271	19	23	218
1909	38	485,192	25,639	137	695,577	26	7	212
1910	47	456,293	27,961	112	908,293	23	12	241
1911	74	407,689	41,201	70	901,759	19	8	255
1912	88	522,455	45,603	103	1,070,664	22	27	267
1913	93	509,846	54,446	146	1,225,116	23	7	274
1914	101	490,875	78,505	128	1,787,308	10	1	276
1915	86	614,998	84,666	117	1,942,423	6	1	262
1916	107	752,635	85,583	125	2,331,687	13	7	266

TENNESSEE.

The profitable production of natural gas in Tennessee in 1916 was limited to the output of 4 wells of small capacity. Two wells in Franklin County supplied gas for domestic use to one family each, and 2 wells in Scott County, 1 of which was completed in 1916, supplied gas for domestic use to five families and a hotel and for industrial use in the shops of the Oneida & Western Railroad at Oneida, as well as for fuel in field operations. Three additional gas wells in Franklin County and 1 each in Fentress and Perry counties were reported as not in use during the year.

ALABAMA.

In 1916 natural gas in sufficient volume to supply the needs of 250 domestic consumers in Fayette was obtained from 4 wells, one of which was completed during the year in the Fayette gas field,

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Fayette County, and enough for the needs of 85 domestic consumers in the town of Jasper was obtained from 2 wells in Walker County.

Wildcat tests drilled in 1916 in quest of petroleum near Mobile, Mobile County, in southern Alabama, resulted in the discovery of numerous pockets of natural gas, but in no commercial production of gas.

Nine gas wells in Madison County and 1 in Winston County in northern Alabama were reported closed in during 1916.

MICHIGAN.

Aside from a small volume of natural gas obtained from oil wells and utilized locally in drilling and pumping operations in St. Clair County, the consumption of natural gas in Michigan is entirely for domestic purposes. Eight shallow wells in Benzie, Macomb, Oakland, St. Clair, Washtenaw, and Wayne counties furnished in 1916 the gas consumed by 11 families. The market value of the entire volume of natural gas consumed in Michigan is estimated at $948. Four exhausted wells were abandoned during the year.

INDIANA.

GENERAL STATEMENT.

As a contributor to the natural gas supply in the United States, Indiana is relatively unimportant, its rank among the States in which natural gas was produced in 1916 being thirteenth, based on the volume, and eleventh, based on market value of the output.

In this State, as in the others of the Ohio Valley, the existence of natural gas had been demonstrated by discoveries in water wells and other borings many years before its presence in commercial quantities was proved. As early as 1876 natural gas in small volume was found in a well drilled for petroleum near Eaton, Delaware County, and there are records of similar discoveries in other localities. It was not, however, until the excitement following the discovery of gas in northwestern Ohio had started the drill anew in Indiana and not until after the successful completion in October, 1886, of well No. 1, at Kokomo, Howard County, credited with an initial open-flow capacity of 2,000,000 cubic feet of gas a day, that the natural-gas resources of Indiana began to be developed. Their subsequent development was rapid, the value of the annual production of natural gas increasing from $300,000 in 1886 to more than $2,000,000 in 1889, to more than $5,700,000 in 1893, and to more than $7,200,000 in 1900. In the succeeding six years it declined rapidly to $1,700,000, the value of the output in 1906, and in the decade since it has decreased slowly but steadily until it is now nearly $100,000 less than in 1887.

Natural gas in Indiana occurs in close association with petroleum. The gas fields of the State are coextensive with its oil fields and the small volume and low pressure of the gas recovered are but a reflection of the advanced stage of exhaustion of the fields both as to oil and as to gas.

The principal source of natural gas in Indiana is the "Trenton" limestone of the Ordovician system, which furnishes the gas produced in the eastern and northeastern parts of the State. In the southwestern part of Indiana natural gas derived from the "Corniferous" limestone of the Devonian system accompanies oil in Pike County

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and in parts of Gibson County, and gas from a sandstone layer in the Chester group of the Mississippian series is found with oil in the Princeton district, Gibson County.

PRODUCTION.

The volume of natural gas produced in Indiana in 1916 is estimated to have amounted to 1,715,499,000 cubic feet, a loss of 545,234,000 cubic feet, or 24 per cent, compared with 1915.

This decline in volume and the loss of 1.42 cents in the average price per thousand cubic feet received for Indiana gas made the market value of the production in 1916 only $503,373, a decrease of $192,007, or 28 per cent, below the market value of the output in 1915.

The production of natural gas credited to Indiana in 1916 was obtained from 2,115 wells, 43 of which were completed during the year and 188 of which were abandoned before its close. Aside from those that also yield oil, there were 1,967 gas wells in service in Indiana at the end of 1916, a net loss of 145 gas wells during the year.

With the exception of a negligible volume piped across the State boundary to consumers in Union City, Ohio, all the gas produced in Indiana in 1916 was consumed within the State.

CONSUMPTION.

The estimated volume of natural gas consumed in Indiana in 1916 was 5,021,364,000 cubic feet, a gain of 502,120,000 cubic feet, or 11 per cent, over the volume consumed in 1915.

The market value of this gas was $1,746,285, a gain of $203,681, or 13 per cent, over the value of the gas consumed in 1915—a result in part of the larger volume involved and in part of an increase of 0.65 cent in the average price per thousand at which the gas was sold. The average retail price in 1916 was 34.78 cents a thousand cubic feet, compared with 34.13 cents in 1915.

The discrepancy of 3,307,865,000 cubic feet between the volume of gas produced in Indiana in 1916 and that consumed in the State in that year was made up by West Virginia and Ohio, the former State supplying more than 99 per cent of the deficiency.

Of the gas consumed, it is estimated that 3,357,872 cubic feet, or 67 per cent of the total volume, valued at $1,259,245, or 72 per cent of the entire market value of the gas consumed, was supplied to 44,118 domestic consumers at an average price of 37.50 cents a thousand. Comparison of these data with corresponding figures of domestic consumption of natural gas in Indiana in 1915 shows in 1916 loss of 4 per cent in volume but gain of 0.1 per cent in the market value of the gas consumed, of 0.2 per cent in the number of consumers, and of 1.61 cents, or 4 per cent, in the average unit cost of natural-gas service to this class of consumers.

The average monthly consumption of natural gas by each domestic consumer in Indiana in 1916 was 6,350 cubic feet, at an average monthly cost of $2.21.

The remaining 33 per cent of the gas consumed in Indiana in 1916, representing 28 per cent of the total market value, was supplied to 995 industrial consumers at an average price of 29.28 cents a thousand. Comparison of the statistics of consumption of natural gas for industrial purposes in Indiana in 1916 and in 1915 reveals in 1916

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gain of 64 per cent in the volume of gas consumed, of 71 per cent in the total market value of the gas consumed, and of 1.21 cents, or 4 per cent, in the average unit cost of industrial gas service, with a loss of 0.4 per cent in the number of consumers. In 1915 the gas supplied to industrial consumers was 22 per cent of the total volume consumed, the increase to 33 per cent in 1916 being merely a reflection of the country-wide increase in industrial activity.

Record of natural-gas industry in Indiana, 1898–1916.

Year.	Gas produced.		Gas consumed.			Wells.		
	Number of producers.	Value.	Number of consumers.		Value.	Drilled.		Productive Dec. 31.
			Domestic.	Industrial.		Gas.	Dry.	
1898	533	$5,060,969	[a] 173,454	1,867	$4,682,401	706	111	3,325
1899	571	6,680,370	[a] 181,440	1,741	[b] 5,833,370	838	109	3,909
1900	670	7,254,539	[a] 181,751	2,751	[b] 6,412,307	861	156	4,546
1901	656	6,954,586	[a] 153,869	2,570	[b] 6,276,119	985	208	4,572
1902	929	7,081,344	101,481	3,282	[b] 6,710,080	1,331	205	5,820
1903	924	6,098,364	90,118	1,020	[b] 5,915,367	895	242	5,514
1904	846	4,342,409	84,862	390	[b] 4,282,409	706	153	4,684
1905	740	3,094,134	63,194	231	[b] 3,056,634	252	74	3,650
1906	578	1,750,715	47,368	156	[b] 1,750,755	159	46	3,523
1907	687	1,572,905	46,210	218	[b] 1,570,005	185	56	3,383
1908	823	1,312,507	42,054	216	[b] 1,312,507	187	41	3,226
1909	1,010	1,616,903	40,565	369	[b] 1,616,903	190	70	2,938
1910	1,027	1,473,403	36,054	282	[b] 1,473,403	69	33	2,955
1911	1,094	1,192,418	31,576	143	[b] 1,192,418	110	32	2,744
1912	1,140	1,014,395	27,165	140	[b] 1,014,395	96	39	2,547
1913	1,100	843,047	39,776	239	[b] 948,278	69	24	2,370
1914	1,029	755,407	43,410	344	[b] 1,422,880	68	19	2,224
1915	999	695,380	44,012	438	[b] 1,542,604	65	11	2,112
1916	995	503,373	44,118	471	1,746,285	43	14	1,967

[a] Number of fires supplied. [b] Includes value of gas consumed in Chicago, Ill.

Depth and rock pressure of wells in Indiana, 1912–1916.

County.	Depth (feet).	Pressure (pounds).				
		1912	1913	1914	1915	1916
Adams	1,000–1,050	100	40– 50	6	10	5
Bartholomew	864– 990	75–125	85–165	80–150	75–160	75–150
Blackford	850–1,200	0– 12	0– 8	0– 20	0– 7	0– 7
Clark	128– 244	27				
Daviess, Martin	300–1,025	7–150	5–165	25– 40	30– 40	35– 60 80
Decatur	700–1,200	5–330	5–350	5–350	10–315	0–320
Delaware	728–1,500	0– 60	0– 50	0– 60	0– 75	0–315
Franklin	728– 730		60			
Grant	830–1,200	2–180	5–200	0– 50	0–100	0– 40
Hamilton	800–1,280	8–235	8–225	0–230	0–235	0– 60
Hancock	700–1,100	5– 80	8–125	6– 80	6– 60	4–200
Harrison	320–1,050	112	50	50	0– 45	0– 50
Henry	800–1,200	0–100	5–150	4–100	5– 50	0–200
Howard	800–1,100	10–180	35–200	30–160	80–200	0–150
Jay	800–1,800	0–220	0– 50	0– 40	0– 50	0– 60
Jefferson	1,300–1,360		20			
Madison	800–1,200	1–175	0–175	0–100	0– 80	0–185
Miami	900–1,000					
Marion, Ripley	880–1,050	150–250	100–160	70–300	100–200	50–200
Pike	1,000–1,400	60–300	25–450	50–225	40– 50	
Randolph	900–1,300	4–140	2–190	1–125	5–100	2–200
Rush	700–1,400	12–300	10–300	15–325	5–300	0–300
Shelby	650–1,020	10–366	15–300	20–300	8–300	0–300
Spencer	1,025	410				
Sullivan	698– 795	40–110	30– 50	50–185		
Tipton	750–1,100	3–180	5–125	3–100	2–100	3–100
Wayne	800–1,150	25– 70	45– 75	45		40– 60

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ILLINOIS.

GENERAL STATEMENT.

The natural-gas industry in Illinois dates from the discovery of natural gas in small volume in shallow wells at Champaign, Champaign County, in 1853. Though natural gas was known and was utilized on a small scale at several localities in the State prior to 1885, it did not assume the status of a public utility in Illinois until 1885, when gas was first piped into Litchfield, Montgomery County, from the small oil and gas field near that town. Not, however, until the opening of the oil fields in the southeastern part of the State in 1905 and 1906 did the natural-gas industry begin to make real headway in Illinois. Following the opening of these fields the consumption of natural gas in this State increased rapidly, the value of the annual production advancing abruptly from about $7,000 in 1905 to $87,000 in 1906, to $644,000 in 1909, and to a maximum of nearly $688,000 in 1911. In the four-year period 1912–1915, it decreased to nearly one-half the record value, but in 1916 this trend was overcome and reversed to the extent of a substantial gain over the value of the output in 1915.

The principal areas of natural-gas production in Illinois are coincident with the oil fields and the relation between production of gas and activity in the quest for oil is close. In the southeastern part of the State natural gas is obtained from a number of productive sands in the Pennsylvanian series ("Coal Measures") and in the deeper-lying Chester group of the Mississippian series. In western central Illinois sands of the Chester group yield gas in Bond County and sands lying near the base of the Pennsylvanian series yield gas in Macoupin County. At numerous localities in northeastern Illinois shallow wells yield gas that is believed to originate in the thick mantle of glacial drift that overlies the hard rocks in this part of the State.

PRODUCTION AND CONSUMPTION.

It is estimated that 3,533,701,000 cubic feet of natural gas was produced and consumed in Illinois in 1916. This volume is greater by 843,108,000 cubic feet, or 31 per cent, than the output in 1915. The gain is accounted for in part by increased conservation of oil-field gas for the manufacture of gasoline and in part by the contribution of the Staunton district, Macoupin County, in which gas was discovered in 1915, but not distributed to consumers until late in 1916.

The market value of the gas produced and consumed in Illinois in 1916 was $396,357, an increase only of $45,986, or 13 per cent, over the market value of the output in 1915, which is accounted for by a decrease of 1.80 cents, or 14 per cent, in the average price per thousand in 1916. The average price in 1916 was 11.22 cents a thousand, compared with 13.02 cents in 1915.

Analysis of the statistics of gas consumed in 1916 shows that the decrease in market value of the gas lies to some extent in the general reduction in the average price per thousand paid both by domestic and by industrial consumers, but chiefly in the greater relative consumption of gas for industrial uses in 1916 than in other recent years.

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Of the total volume of gas consumed in Illinois in 1916 it is estimated that 635,298,000 cubic feet, representing only 18 per cent of the total volume, valued at $169,729, or 43 per cent of the total market value, was distributed to 14,485 domestic consumers at an average price of 26.72 cents a thousand, and that the remaining 82 per cent of the total volume, representing 57 per cent of the total market value, was distributed to 121 industrial consumers at an average price of 7.82 cents a thousand.

Of the volume consumed in Illinois in 1915 domestic consumers utilized 26 per cent and industrial consumers 74 per cent, the former paying in that year an average of 27.25 cents a thousand and the latter an average of 7.97 cents a thousand for their gas.

With regard to the relative volume of gas sold at domestic rates in the two years, the sales in 1916 were less by 69,398,000 cubic feet, or 10 per cent, than in 1915, though the number of consumers increased from 8,610 in 1915 to 14,485 in 1916, a gain of 68 per cent.

Unless the fact is borne in mind that 68 per cent of the domestic consumers of record in Illinois at the end of 1916 were favored with natural-gas service only in the last four months of that year, conclusions as to the average volume of natural gas utilized by each domestic consumer in any specified period will be ill founded. Making due allowance for this circumstance, the approximate monthly consumption of natural gas by each domestic consumer in Illinois in 1916 was 5,000 cubic feet, this volume being supplied at an average monthly cost of $1.34.

The volume of natural gas consumed for industrial purposes in Illinois in 1916 was greater by 912,506,000 cubic feet, or 46 per cent, than that so consumed in 1915, and its market value was greater by $68,307, or 43 per cent, despite a loss of 0.15 cent in the average unit price paid for industrial gas in 1916.

The only development of consequence in the natural-gas industry in Illinois in 1916 was in the matter of the utilization of the supply of natural gas from the Staunton dome, in Macoupin County. The discovery of gas in this locality was fully reported on page 960 of the report of this series for 1915.[1] Mains were laid in 1916 connecting this field with Staunton, Edwardsville, Marysville, Collinsville and Belleville, and during the last four months of the year natural gas was distributed to a large number of consumers in these municipalities.

The statistics of natural-gas consumption in Illinois presented in this chapter include the volume and value of the gas piped from Illinois to supply consumers in Vincennes, Ind.

[1] U. S. Geol. Survey Mineral Resources, 1915, pt. 2, p. 960, 1917.

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Record of natural-gas industry in Illinois, 1906–1916.

Year.	Gas produced.		Gas consumed.			Wells.		
	Number of producers.	Value.	Number of consumers.		Value.	Drilled.		Productive Dec. 31.
			Domestic.	Industrial.		Gas.	Dry.	
1906	66	$87,211	1,429	2	$87,211	.....	.....	200
1907	128	143,577	2,126	61	143,577	94	41	283
1908	185	446,077	a 7,377	a 204	a 446,077	121	42	400
1909	194	644,401	a 8,458	a 518	a 644,401	56	11	423
1910	207	613,642	a 10,109	a 261	a 613,642	64	31	458
1911	225	687,726	a 10,078	a 293	a 687,726	69	78	458
1912	223	616,467	a 10,691	a 212	a 616,467	56	147	453
1913	231	574,015	a 10,423	a 279	a 574,015	60	119	455
1914	235	437,275	a 8,952	a 153	a 437,275	38	114	416
1915	226	350,371	a 8,610	a 134	a 350,371	28	67	372
1916	218	396,357	a 14,485	a 121	a 396,357	36	126	343

a Includes number of consumers and value of gas consumed in Vincennes, Ind., and in 1916 includes some consumers who use mixed gas.

Depth and rock pressure of wells in Illinois, 1912–1916.

County.	Depth (feet).	Pressure (pounds).				
		1912	1913	1914	1915	1916
Bond	925–1,100	40–410	35–355	40–350	100–350	75–325
Lawrence	700–1,900					
Bureau	85– 357	0– 80	0– 42	0– 35	0– 25	0– 42
Champaign	80– 140	0– 20	0– 30	0– 30	0– 45	0– 45
Clark	250– 640	15–105	0– 30	.....	20– 35	0– 30
Crawford	400–1,600	20–200	20–350	25–450	25–200	0– 30
Cumberland	500–1,000	.....	.....	65	.....	.....
Dewitt	80– 180	0– 50	0– 25	0– 20	0– 50	0– 20
Edgar	230– 600	75–130	50–135	80–135	40–130	20–130
Lee	126– 280	12– 28	12– 20	15– 28	2– 28	1– 28
Logan	84– 90	.....	.....	.....	.....	.....
McHenry	160– 372	.....	.....	.....	.....	.....
McLean						
Macoupin	447– 505	.....	.....	.....	.....	157–170
Montgomery	55– 67	.....	1– 2	.....	.....	.....
Morgan	224– 400	0–100	0– 96	0– 20	0– 35	0– 40
Pike	88– 350	0– 10	0– 9	0– 53	0– 10	0– 10

MISSOURI.

The volume of natural gas produced profitably in Missouri in 1916 is estimated at 69,236,000 cubic feet, and its value at $17,594, representing an average price of 25.41 cents a thousand cubic feet—a gain of 150 per cent in volume, and of 128 per cent in market value, but a loss of 2.56 cents in average unit price, compared with 1915.

Outside of Jackson County, where gas produced locally is distributed to residences in Martin City and vicinity, and of Platte County, where gas also produced locally, is supplied to consumers in Parkville, the production of natural gas in Missouri is restricted to the output of scattered wells in Bates, Cass, and Johnson counties, which yield only enough gas to satisfy the domestic needs of two or three families each.

Aside from the natural gas produced within the boundaries of this State, a large volume of gas, accounted for in the statistics for Kansas

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and Oklahoma where it is produced, is piped into Missouri annually and consumed in the smelting of lead and zinc in the Joplin region in the southwestern part of the State and in Kansas City and St. Joseph in the northwestern part.

KANSAS.

GENERAL STATEMENT.

The natural-gas industry in Kansas dates back to 1873, when gas from the Acers Mineral Well at Iola, Allen County, was used as an illuminant in a neighboring sanitarium erected for the primary purpose of exploiting the medicinal properties of the mineral water obtained from the same well. In 1882 gas was found in abundance in wells drilled 7 miles north of Paola, Miami County, and in 1884 mains were laid from this district to Paola and the distribution of gas to consumers in that town was begun. About 1887 natural gas from near-by wells was introduced into the town of Fort Scott, Bourbon County, and in 1892 the distribution of gas from wells of large capacity west and northwest of Coffeyville, Montgomery County, was begun in the latter town. In 1893 Cherryvale, in the northeastern part of the same county, was first supplied with natural gas from wells east of town, and Independence, near the center of the county, was supplied from wells 4 miles to the east. The adoption of natural gas as a fuel in the zinc smelters at Cherryvale in 1898 established the the natural-gas industry of Kansas on a permanent basis, and its subsequent development was rapid. In 1905 natural gas mains were laid from the fields in Montgomery County to the Joplin lead and zinc district in southwestern Missouri and in 1906 gas from the Allen and Neosho County fields was piped into Kansas City.

From only a few hundred dollars in 1882 the value of the gas produced annually in Kansas increased slowly to $50,000 in 1893, then rapidly to $112,000 in 1895, to $1,124,000 in 1903, and to a maximum of $8,294,000 in 1909, subsequent to which it declined steadily to $3,288,000 in 1913, since which year it has gradually increased with the development of prolific gas fields in Butler County, though it is still far below the maximum.

Natural gas was produced profitably in Kansas in 1916 in 23 counties, all in the eastern third of the State. Petroleum and natural gas in this State occur in sandstone or limestone layers in the Pennsylvanian series ("Coal Measures"), the most productive zone being that of the Cherokee shale, at the base of the series. Lenticular sandstone layers interbedded with the Cherokee shale constitute the principal reservoirs of oil and gas in the State.

PRODUCTION.

The volume of natural gas produced in Kansas in 1916 was greater than that produced in this State in any other recent year since 1911. It amounted to 31,710,438,000 cubic feet and exceeded the output in 1915 by 4,664,530,000 cubic feet, or 17 per cent. The value of this gas at the point of consumption was $4,855,389, a gain of $818,378, or 20 per cent, over the value of the output in 1915, this gain being accounted for in part by the increased volume of gas and in part by an increase from 14.93 cents to 15.31 cents in the average price per thousand cubic feet at which the gas was sold in 1916.

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Credit for the augmented production in 1916 belongs almost wholly to Butler County and was due principally to the extensive activity in the quest for petroleum in the Augusta and Eldorado districts in that county. In all 75 new gas wells were completed, 7 exhausted wells were abandoned, and 234 gas wells were in service in Butler County in 1916, exclusive of the wells that produced both gas and petroleum.

In Chautauqua and Montgomery counties the usual activity in the quest for natural gas prevailed, but no new territory of consequence was added to the areas already proved productive.

In the State as a whole activity in drilling for natural gas was less than in 1915 and was attended with poorer success, as far as the number of wells is concerned. In 1916 a total of 654 wells were drilled for gas, of which 461, or 70 per cent, were successful and 193, or 30 per cent, were unsuccessful. In 1915 there were 748 wells completed, of which 554, or 74 per cent, were successful. The number of unsuccessful tests reported in 1916 was only 1 less than the number reported in 1915. At the end of 1916 there were 2,513 gas wells, exclusive of the wells that produce both oil and gas, in service in Kansas, a net gain of 70 wells over the number in service at the end of 1915.

CONSUMPTION.

Including a relatively small volume of natural gas piped to Missouri and consumed in the smelter district about Joplin, the volume of natural gas consumed in Kansas in 1916 was 60,564,112,000 cubic feet, a gain of 11,692,817,000 cubic feet, or 24 per cent, over the volume consumed in 1915.

The market value of this gas was $9,731,518, a gain of $1,557,229, or 19 per cent, over the value of the gas consumed in Kansas in 1915. The failure of the total market value to increase in the same ratio as the volume of gas consumed is accounted for by a decrease from 16.73 cents to 16.07 cents in the average price per thousand cubic feet in 1916.

It is estimated that 20,876,693,000 cubic feet of gas, or 34 per cent of the total volume consumed in Kansas in 1916, valued at $5,314,011, or 55 per cent of the total market value, was distributed to 202,222 domestic consumers in Kansas and southeastern Missouri at an average price of 25.45 cents a thousand cubic feet, and that the remaining 66 per cent of the volume, representing 45 per cent of the total market value of the gas consumed, was distributed to 1,354 industrial consumers at an average price of 11.13 cents a thousand.

With regard to the consumption of natural gas for domestic purposes in Kansas in 1915 and 1916, a comparison of the statistics for the two years shows in 1916 gain of only 1 per cent in volume and of 0.5 per cent in the number of consumers supplied, but loss of 0.3 per cent in the total market value of the gas involved on account of a decrease of 0.38 cent, or 1.5 per cent in the average price per thousand paid for natural gas service by this class of consumers.

The average volume of natural gas consumed monthly by each domestic consumer in Kansas in 1916 was 8,600 cubic feet at an average monthly cost of $2.19.

With regard to the consumption of gas for industrial purposes a comparison of the statistics for the same two years shows in 1916 loss of 7 per cent in the number of consumers, but gain of 40 per cent in

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the volume of gas consumed, of 55 per cent in the total market value of that gas, and of nearly 11 per cent in the average price per thousand paid for it.

Much of the increase recorded is accounted for in the greatly augmented requirements of natural gas for fuel in lead and zinc smelters. It is estimated that in 1916 a total of 15,542,197,000 cubic feet of gas, valued at $1,750,726, was distributed at an average price of 11.26 cents a thousand, to the smelters. Comparison of these data with corresponding items for 1915 shows in 1916 gain of 82 per cent in the volume of gas consumed in Kansas in the smelting of metals, of 106 per cent in the total market value of that gas, and of 1.36 cents, or 14 per cent, in the average unit price paid for it.

About 2,690,917,000 cubic feet of gas, valued at $242,457, an average price of 9.01 cents a thousand, was distributed in 1916 to cement plants in Kansas, and about 3,962,940,000 cubic feet, valued at $362,070, an average price of 9.14 cents a thousand was distributed to manufacturers of brick, glass, and clay products.

Record of natural-gas industry in Kansas, 1898–1916.

Year.	Gas produced.		Gas consumed.			Wells.		
	Number of producers.	Value.	Number of consumers.		Value.	Drilled.		Productive Dec. 31.
			Domestic.	Industrial.		Gas.	Dry.	
1898	29	$174,640	[a] 6,186	44	$174,610	34	18	121
1899	31	332,592	[a] 10,071	71	332,592	44	22	160
1900	32	356,900	[a] 9,703	65	356,900	54	15	209
1901	48	659,173	[a] 10,227	72	659,173	71	35	276
1902	80	824,431	13,488	91	824,431	144	63	404
1903	120	1,123,849	15,918	143	1,123,849	295	66	666
1904	190	1,517,643	27,204	298	1,517,643	378	135	1,029
1905	171	2,261,836	46,852	601	2,265,945	340	157	1,142
1906	130	4,010,986	79,270	990	[b] 4,023,566	331	99	1,495
1907	196	6,198,583	149,327	1,605	[b] 6,208,862	361	163	1,760
1908	212	7,691,587	168,855	1,162	[b] 7,691,587	403	208	1,917
1909	199	8,293,846	182,657	1,160	[b] 8,356,076	452	214	2,138
1910	204	7,755,367	186,333	1,412	[c] 9,335,027	392	195	2,149
1911	232	4,854,534	199,523	907	[c] 9,493,701	301	152	2,033
1912	253	4,264,706	195,446	1,104	[c] 8,521,858	435	200	2,106
1913	305	3,288,394	195,131	950	[c] 6,983,802	506	253	2,297
1914	353	3,340,025	187,714	1,079	[b] 7,163,746	445	219	2,261
1915	371	4,037,011	201,133	1,446	[b] 8,174,289	554	194	2,443
1916	414	4,855,389	202,222	1,354	[b] 9,731,518	461	193	2,513

[a] Number of fires supplied.
[b] Includes gas taken from Kansas and consumed in Missouri.
[c] Includes gas taken from Kansas to Missouri; also gas piped from Oklahoma to Kansas and Missouri.

Depth and rock pressure of wells in Kansas, 1912–1916.

County.	Depth (feet).	Pressure (pounds).				
		1912	1913	1914	1915	1916
Allen	500–1,500	10–300	5–260	6–240	5–300	4–270
Anderson	230–1,070	30–240	65–250	65–225	60–225	63–165
Bourbon	150–800	40	75	75	80	.....
Chase	64–1,100	7–80	3–95	10–[a]160	6–160	8–130
Crawford	97–680	15–50	40–50	30–90	40–176	25–80
Cowley	575–1,500					
Chautauqua	300–1,900	50–300	35–410	40–210	25–425	30–60

[a] New wells.

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Depth and rock pressure of wells in Kansas, 1912–1916—Continued.

County.	Depth (feet).	Pressure (pounds).				
		1912	1913	1914	1915	1916
Douglas	350– 550	10– 280	20– 60	10–a130	20–610	55– 80
Johnson	130– 950					
Ellsworth	950–1,250	125– 270	240– 270	160– 250	195–275	200–250
Elk	500–1,887	100	90– 100	75	40	100–550
Butler	1,330–2,650	60–a525	550–a560	a400–a600	300–500	30–300
Woodson	650–1,430			90– 250	200	125
Greenwood	350– 400					
Labette	320–1,000	23– 185	20– 240	50– 200	42–195	50–300
Linn	85– 750	6– 70	20– 100	20– 100	10–100	15–110
Franklin	300– 720	3– 260	1– 500	50– 240	112	40–112
Miami	200–1,150			40– 120	45–100	50–100
Montgomery	160–1,600	2–a515	5– 700	15– 400	15–175	8–150
Morris	600				250	300
Neosho	281–1,200	28– 250	15– 325	25–a360	0–260	0–260
Wilson	250–1,725	15– 380	15– 285	12–a350	30–475	7–600
Wyandotte	271– 800	40– 125	30– 125	85	15– 75	0–140

a New wells.

OKLAHOMA.

GENERAL STATEMENT.

The natural-gas resources of Oklahoma are closely associated with petroleum and the development of the natural-gas industry in this State has closely paralleled the development of its vast resources of petroleum. The earliest recorded use of natural gas on a commercial scale in Oklahoma was at Red Fork, Tulsa County, where it was used as fuel for drilling purposes and as a source of heat and light in a few houses in 1902. In 1903 natural gas was used for drilling purposes near Lawton, Comanche County, near Pawhuska, Osage County, and near Newkirk, Kay County. In 1904 natural gas was distributed to domestic consumers in Tulsa, Bartlesville, Ochelata, Pawhuska, and Red Fork, and to brickworks near Red Fork. The subsequent growth of the natural-gas industry in Oklahoma has been rapid and has by no means spent its force. Since 1911 Oklahoma has ranked third among the gas-producing States, on the basis of the volume of gas produced, and its advance to second place in 1917 seems inevitable.

Natural gas was produced profitably in Oklahoma in 1916 in 31 counties lying in the eastern half of the State.

Petroleum and natural gas in Oklahoma are found in sandstone and, less commonly, in limestone layers of variable thickness occurring at numerous horizons in the succession of strata between the base of the Mississippian series (lower Carboniferous) below and the lower portion of the Permian series above. By far the greater part of the production, both of petroleum and of natural gas, is derived from "sands" in the intervening Pennsylvanian series (upper Carboniferous).

PRODUCTION.

The volume of natural gas produced profitably in Oklahoma in 1916 exceeded the volume so produced in this State in any preceding year. This volume, which is estimated at 123,517,385,000 cubic feet, was greater by 36,000,632,000 cubic feet, or 41 per cent, than the output in 1915, which was itself a record yield.

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The market value of this gas was $11,983,774, a gain of $2,787,970, or 30 per cent, over the value of the gas produced in 1915. The failure of the statistics of value to record an increase commensurate with the volume is accounted for by the facts that they are based on the prices received for gas at the point of consumption and that relatively more Oklahoma gas was distributed at industrial rates than at domestic rates in 1916, as compared with 1915.

The influence of the increased distribution of gas to industrial consumers is shown in the statistics of the average price per thousand received for Oklahoma gas in 1916. This was 9.70 cents, compared with 10.51 cents in 1915, a loss of 0.81 cent, or nearly 8 per cent, in 1916.

The greater part of the gas produced in Oklahoma in 1916 came from the Cushing district and its southward extension, the Shamrock district, in Creek County. In the Cushing district the open-flow capacity of the gas wells completed in 1916 averaged appreciably lower than that of the wells completed in 1915. Development work in the Shamrock district resulted in the completion of many gas wells of large capacity, the largest of which was probably the initial well of the McMann Oil Co., on the Williams farm in sec. 4, T. 16 N., R. 7 E. This well was completed early in February and was credited with an initial open-flow capacity of 70,000,000 cubic feet of gas a day from the Bartlesville sand. The completion of wells credited with initial open-flow capacities of 30,000,000 to 50,000,000 cubic feet of gas a day was by no means an uncommon feature of the development work in this district in 1916. Some of the gas produced in this district was unavoidably lost, but much of it was either piped away for immediate consumption or sealed off in the productive sands for future use.

In western Pawnee County new territory of considerable promise was opened in January, 1916. The initial test was drilled by Watchorn and others in sec. 32, T. 23 N., R. 3 E., and completed as a gas well credited with a capacity of 35,000,000 cubic feet from two sands reached at reported depths of 1,840 and 2,150 feet.

Near Ingalls in the east central part of Payne County a prolific area of gas production was proved in 1916 in secs. 27 and 34, T. 19 N., R. 4 E., one well in sec. 27 of this township completed in August by the Fortuna Oil Co. being credited with an initial open-flow capacity of 60,000,000 cubic feet of gas a day. In the southern part of Washington County a number of gas wells ranging in initial open-flow capacity between 5,000,000 and 10,000,000 cubic feet a day were completed by the Quapaw Gas Co. in 1916 near Ochelata. The interesting feature of this district lies in the fact that the gas is obtained from what is believed to be the Pitkin limestone near the top of the Mississippian series and in this locality about 300 feet below the Bartlesville sand, the principal source of oil and gas in northeastern Oklahoma.

In the Blackwell district, Kay County, the results of drilling in 1916 added further proof of the enormous potentialities for gas production possessed by this district. A few gas wells of large capacity were completed during the year, but in most of the wells the gas was "mudded off" in the productive sand for future use.

In Noble County natural-gas territory of much promise was opened in July near Billings by the completion as a gas well having an esti-

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mated initial capacity of 6,000,000 cubic feet of a wildcat test drilled by the Mid-Co. Petroleum Co., on the Hoover farm in sec. 22, T. 23 N., R. 2 W.

In the southwestern part of Wagoner County development work in the Stone Bluff pool, discovered late in 1915, resulted in the completion of a number of prolific gas wells.

The discovery at a depth of 2,972 feet of a flow of gas estimated at 5,000,000 cubic feet a day in a test well drilled in sec. 16, T. 8 N., R. 11 E., aroused considerable speculation as to the presence of an important gas field near Lamar, Hughes County.

Aside from the occasional completion of a prolific gas well in the southeastern part of the Healdton district, Carter County, interest in natural-gas developments in this locality in 1916 was centered in the Fox pool, 6 miles north of this district, where it will be recalled a gas well credited with an initial capacity of 20,000,000 cubic feet was completed by the Gypsy Oil Co. late in December, 1915. During 1916 gas from this well was utilized as fuel for the drilling of additional wells in this locality and was piped to Ardmore to increase the failing supply piped to that city from the old Wheeler field. In October, 1916, one additional gas well was completed in this new field. It was drilled by Phillips & Franklin in sec. 29, T. 2 S., R. 3 W., and was credited with an open-flow capacity of 45,000,000 cubic feet of gas. Late in December well No. 2 of the Gypsy Oil Co., in sec. 28, was drilled into a prolific gas sand encountered at a reported depth of 2,080 feet, and at the end of 1916 efforts were being made to seal off the productive sand in order that the well might be deepened. Its open-flow capacity was estimated at 50,000,000 cubic feet of gas a day.

Exclusive of the wells that yielded both oil and gas there were 386 gas wells completed in Oklahoma in 1916. At the end of the year 1,409 gas wells were in service in this State.

Aside from supplying the gas required by consumers residing in Oklahoma, the gas fields of this State supplied a large volume of natural gas to consumers in Missouri, Kansas, and Arkansas.

CONSUMPTION.

Including the gas piped from Oklahoma to the lead and zinc district of southwestern Missouri, the volume of natural gas consumed in Oklahoma in 1916 was about 93,704,221,000 cubic feet. This volume was greater by 28,012,855,000 cubic feet, or 30 per cent, than the volume consumed in 1915. Its market value was $7,062,142, a gain of $2,003,616, or 28 per cent, over the value of the gas consumed in 1915.

The average price per thousand paid by all classes of consumers to which this gas was distributed, was 7.54 cents in 1916, compared with 7.70 cents in 1915 and 7.61 cents in 1914.

Of the total volume of gas consumed in 1916 it is estimated that 10,723,336,000 cubic feet, market value $1,915,758, was distributed to 79,724 domestic consumers, at an average price of 17.87 cents a thousand, and that the remaining volume of 82,980,885,000 cubic feet, market value $5,146,384, was distributed to 2,327 industrial consumers, at an average price of 6.20 cents a thousand.

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Comparison of the statistics of natural-gas consumption for domestic purposes in 1915 and 1916 shows in 1916 increase of 11,850, or 17 per cent, in the number of consumers favored with natural-gas service, but of only 7 per cent in the volume of gas used, and of 6 per cent in its total market value, despite a reduction of 0.10 cent, or 1 per cent, in the average price per thousand paid for the gas. Calculation based on the total number of domestic consumers favored with natural-gas service at end of 1916 indicates that the average monthly consumption of natural gas by each consumer in 1916 was 11,200 cubic feet and that the average monthly cost of this service was only $2. The average actual consumption was undoubtedly slightly greater than is indicated by these figures as a consequence of the fact that 17 per cent of the domestic consumers were supplied with gas during only a part of the entire year.

Comparison of the statistics of natural gas consumed for industrial purposes in the same two years shows in 1916 gain of 110, or 25 per cent, in the number of consumers supplied, of 49 per cent in the volume of gas consumed, of 58 per cent in the market value of that gas, and of 0.35 cent, or 6 per cent, in the average price per thousand paid for it.

A further analysis of the statistics of natural gas consumed for industrial purposes in 1916 indicates that 46,246,844,000 cubic feet, market value $2,701,158, was distributed to 366 industrial plants for direct consumption in manufacturing processes, such as the smelting of metals, the making of glass, the burning of brick, and the manufacture of carbon black, at an average price of 5.84 cents a thousand, and that the remaining 36,734,041,000 cubic feet, market value $2,445,226, was distributed to 1,961 industrial plants for use as fuel in the generation of power, as in gas engines and under steam boilers, at an average price of 6.66 cents a thousand.

Of the volume distributed in 1916 for direct use in manufacturing, it is estimated that 26,209,069,000 cubic feet, market value $1,385,059, an average price of 5.3 cents a thousand, was consumed in the smelting of metals in Oklahoma. Compared with the consumption for this purpose in 1915 these data show in 1916 gain of 62 per cent in volume, of 73 per cent in market value, and of 0.4 cent, or 8 per cent, in average price per thousand.

Smelters in Oklahoma supplied with natural gas in 1916 are located as follows: Bartlesville, 3 plants, owned by the National Zinc Co. and the Bartlesville Zinc Co.; Collinsville, 2 plants, owned by the Bartlesville Zinc Co. and the Tulsa Fuel & Manufacturing Co.; Henryetta, 3 plants, owned by the Western Spelter Co., the Henryetta Spelter Co., and the Eagle-Picher Lead Co.; Kusa, 2 plants, owned by the Kusa Spelter Co. and the Oklahoma Spelter Co.; Checotah, 1 plant, owned by the United States Smelting Co.; Quinton, 1 plant, owned by the Quinton Spelter Co.; Sand Springs, 1 plant, owned by the United States Zinc Co.; and Blackswell, 1 plant, owned by the Bartlesville Zinc Co.

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Record of natural-gas industry in Oklahoma, 1906–1916.

Year.	Gas produced.		Gas consumed.			Wells.		
	Number of producers.	Value.	Number of consumers.		Value.	Drilled.		Productive Dec. 31.
			Domestic.	Industrial.		Gas.	Dry.	
1906	50	$259,862	8,391	202	$247,282	81	33	239
1907	107	417,221	11,038	277	406,942	99	41	344
1908	115	860,149	17,567	356	860,159	73	40	374
1909	131	1,806,193	32,907	1,527	1,743,963	97	35	454
1910	168	3,490,704	38,617	1,557	1,911,044	93	58	509
1911	204	6,731,770	44,854	1,507	2,092,603	303	143	732
1912	242	7,406,528	47,017	1,551	3,149,376	329	197	936
1913	347	7,436,389	49,308	1,793	3,740,981	423	298	1,052
1914	437	8,050,039	62,390	1,951	[a] 4,226,318	388	182	1,205
1915	434	9,195,804	67,874	1,551,	[a] 5,058,526	209	118	1,229
1916	544	11,983,774	79,724	2,327	[a] 7,062,142	386	231	1,409

[a] Includes some gas piped from Oklahoma to Missouri.

Depth and rock pressure of wells in Oklahoma, 1912–1916.

County.	Depth (feet).	Pressure (pounds).				
		1912	1913	1914	1915	1916
Cherokee	600– 650					
Hughes	1,000–2,000	200	10–350		500	400
Carter	590–2,000			30–325	50–370	300–900
Comanche	340–1,000			286–400	78	200–250
Craig	500– 520					
Latimer	1,575–1,600			151–400		
Sequoyah	1,200					
Creek	400–2,900	40–850	20–900	40–800	40–400	75–690
Garfield	1,150–1,170					
Kay	400–3,400	165–365	40–650	35–450	50–[a] 1,500	40–[a] 1,200
Kiowa	350– 825			30		
Le Flore	1,300–3,000	350–355	300–375	385	140–350	260–350
McIntosh	962–2,740	150–600	150–400	[a] 900	110–[a] 1,200	500–610
Marshall	420– 600			150	135–150	150–225
Mayes	102– 640				40– 80	5– 45
Muskogee	700–2,200	15–350	10–350	20–275	20	120–805
Nowata	450–1,700	25–150	25–300	39–150	85–310	
Okfuskee	1,450–2,460			[a] 790	[a] 790	700–790
Okmulgee	600–2,600	300	80–[a] 800	80–[a] 840	300–[a] 1,000	60–710
Osage	750–2,500	200–780	100–700	150–[a] 800	150–680	50–740
Pawnee	1,000–3,150	40–800			[a] 860	800
Coal	400–3,300			110–425		100–550
Pittsburg						
Pontotoc	1,000–3,000					
Greer	390– 565					
Payne	2,940–3,150			[a] 800	[a] 900	400
Rogers	380–1,800	40–525	25–500	145–400	50–350	30–400
Stephens	600–1,200	300–325	250–330	240–345	263	156
Tulsa	580–2,200	50–625	100–650	70–525	40–600	30–500
Wagoner	550–1,700			165–405	230–325	206–520
Washington	315–2,260	10–250	19–350	25–[a] 635	30–300	50–400

[a] New wells.

ARKANSAS.

PRODUCTION.

The volume of natural gas produced in Arkansas in 1916 is estimated at 2,387,935,000 cubic feet, a gain of about 248 per cent over the output in 1915. The market value of this gas was $241,896 and the average price at which it was sold to consumers was 10.13 cents a thousand cubic feet.

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Credit for the large increase in the production of natural gas in this State belongs to the Kibler field, discovered late in 1915, in Crawford County, 7 miles east of Van Buren, the county seat. In this district, which at the end of 1915 had but one productive gas well, 38 wells were drilled in 1916. Of these 24 were successful gas wells, the remainder being barren. The wells in this field range in depth from 2,000 to 2,600 feet and in initial open-flow capacity from 3,000,000 to 25,000,000 cubic feet of gas a day. The average rock pressure of the gas in this field at the end of 1916 was about 220 pounds to the square inch, compared with 265 pounds when the field was opened.

Three pipe lines constructed during the year by the Clear Creek Oil & Gas Co., the LaSalle Oil & Gas Co., and the Twin City Pipe Line Co., respectively, provided ample facilities for marketing the output of this field to consumers in Fort Smith, South Fort Smith, Van Buren, and Kibler.

In the Massard Prairie district, in Sebastian County, which for a number of years has been the principal source of the gas consumed in Fort Smith and Van Buren, no new wells were drilled during 1916. At the end of the year there were 83 gas wells in service in this district, on which the rock pressure averaged about 21 pounds to the square inch, compared with 25 pounds at the end of 1915.

In the Hartford district, in southern Sebastian and northern Scott counties, which supplies the gas consumed in the towns of Mansfield and Huntington, there was no material change in the natural gas situation in 1916. At the end of the year 11 gas wells, with an average closed pressure of 290 pounds to the square inch, were in service in this district.

Outside these districts the only gas produced commercially in Arkansas in 1916, came from a 3,000-foot well in Bradley County that furnished gas for domestic consumption in a small hotel in Vick.

CONSUMPTION.

The volume of natural gas consumed in Arkansas in 1916 was approximately 3,347,398,000 cubic feet, a gain of 2,355,599,000 cubic feet, or 238 per cent, over the volume consumed in 1915. The value of this gas at the point of consumption was $287,399, a gain of $94,307, or 49 per cent, over the value of the gas consumed in 1915. The notable discrepancy between the rates of increase of these two factors is accounted for by the fact that practically all the gas marketed in 1916 from the Kibler field was sold at industrial rates for consumption in lead and zinc smelters in Fort Scott and Van Buren. Because of the proximity of this field to these consuming centers and of the abundance of natural gas available, domestic consumers in these cities were favored with a lower rate for natural gas service than in 1915.

The average price paid for natural gas by consumers in Arkansas in 1916 was 8.59 cents a thousand cubic feet, compared with 19.47 cents in 1915, a decrease of 10.88 cents, or 56 per cent, in 1916.

Of the total volume of gas consumed in 1916 it is estimated that 713,047,000 cubic feet, or only 21 per cent, valued at $153,208, or 53 per cent of the total value of the gas consumed, was distributed to 6,399 domestic consumers at an average price of 21.49 cents a

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thousand, the remaining 79 per cent of the total volume, representing 47 per cent of the total market value, being distributed to 17 industrial consumers at an average price of 5.09 cents a thousand.

Of the total volume of natural gas consumed in Arkansas in 1915 it is estimated that 624,264,000 cubic feet, or 63 per cent, valued at $159,606, or 83 per cent of the total market value of the gas consumed in that year, was distributed to 5,797 domestic consumers at an average price of 25.57 cents a thousand and that the remaining 37 per cent of the volume, representing 17 per cent of the total market value in that year, was distributed to 9 industrial consumers at an average price of 9.11 cents a thousand.

With appropriate allowance for the fact that the 602 new domestic consumers of natural gas in Arkansas in 1916 were not supplied prior to August, the average volume of gas consumed monthly in 1916 by each domestic consumer in this State was 9,825 cubic feet, which volume was obtained at an average monthly cost of $2.11.

In addition to the gas accounted for in the statistics of consumption presented here, which include a small volume of gas piped into this State from eastern Oklahoma, a considerable volume of natural gas, piped into the State from Louisiana and accounted for in the statistics for that State, was consumed in the cities and towns of southern Arkansas in 1916.

LOUISIANA.

PRODUCTION.

The volume of natural gas produced in Louisiana in 1916 was greater than that produced in this State in any preceding year in the history of the local gas industry. It amounted to approximately 32,080,975,000 cubic feet, and at the average selling price of 8.29 cents a thousand cubic feet, added $2,660,445 to the mineral wealth of the State in that year.

Compared with statistics for 1915 these data show gain in 1916 of 6,540,583,000 cubic feet, or 26 per cent, in the volume of gas produced, and of $496,511, or 23 per cent, in its total market value, but a decline of 0.18 cent, or 2 per cent, in the average unit price at which this gas was sold.

As the available supply of natural gas in Louisiana is considerably in excess of the facilities for marketing it, the increase in production can be accounted for in part by the extension of existing transmission lines. As the production of natural gas in this State is largely incidental to the development of its oil fields some part of the increase in gas production in 1916 must be ascribed to the fact that activity in the quest of petroleum in Louisiana was 18 per cent greater in that year than it was in 1915. Other factors contributing to this increase include augmented demands for natural gas for drilling purposes in the oil fields, for consumption as fuel by large industrial consumers, and for utilization in five new plants for the extraction of gasoline from natural gas installed in this State in 1916.

A fair proportion of the increased output of natural gas in Louisiana in 1916 came from wells in the immediate vicinity of Shreveport in the southern part of Caddo Parish. The remarkable success attained in the quest of natural gas in this locality in 1915 resulted in the drilling of additional wells in 1916 and in the completion of a number

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of gas wells of large capacity in the Harts Island district, just south of Shreveport, in the Cross Lake district, a few miles west of this city, and in the area northwest of Shreveport, between this city and Blanchard.

Persistent efforts, over a period of several years, to find petroleum in commercial quantities in Bossier Parish were rewarded in 1916 by the discovery of a prolific gas field in the vicinity of Elmgrove, about 20 miles southeast of Shreveport. The discovery well drilled by the Atlas Oil Co. was completed in January on the Elston lease in sec. 20, T. 16 N., R. 11 W., and was credited with an initial flow of 3,000,000 cubic feet of gas a day from a sand reached at a depth of about 900 feet. The completion of well No. 2 on this lease in February as a 30,000,000-foot gasser furnished the real incentive for additional drilling in this locality. Several gas wells of large capacity were completed in this new field during 1916, but to the end of the year the only market for the gas was the very limited one provided by the requirements for drilling purposes of companies operating in the same field.

A gas field of considerable potential importance was also discovered in 1916 in Morehouse Parish, in the northeastern part of Louisiana. The discovery well drilled by the Progressive Oil & Gas Co. was completed in September on the Spyker tract in sec. 9, T. 20 N., R. 5 E., and was credited with an initial open-flow capacity estimated at 5,000,000 cubic feet a day and a rock pressure of 800 pounds to the square inch, from a sand reached at a depth of about 2,200 feet. The completion in November by the same company of its second well, No. 1 Fisher, in sec. 33 of the township to the north, as a 10,000,000-foot gasser at a depth of about 2,250 feet resulted in the starting of a number of other wells in southern Morehouse and northern Ouachita parishes, which, however, remained uncompleted to the end of 1916. Plans were made to pipe the gas from this field to Bastrop, Monroe, and West Monroe in 1917.

The greater part of the natural gas produced in Louisiana in 1916 came as usual from the oil districts in Caddo, De Soto, and Red River parishes; a small percentage, however, consumed near the source of production, was obtained from scattered wells in Natchitoches, Rapides, Richland, La Fourche, Ouachita, Claibourne, Calcasieu, Terrebonne, and Vermilion parishes.

During 1916 the number of producers of natural gas in Louisiana increased from 57 to 78, and at the end of that year there were 263 gas wells in service in the State, compared with 253 at the end of 1915.

CONSUMPTION.

Including the gas piped from Louisiana to adjacent parts of Arkansas and Texas, the volume of natural gas consumed in Louisiana in 1916 was equivalent to the volume produced, as no gas from other States is consumed in this State.

Of the total volume consumed in 1916 about 3,890,552,000 cubic feet, or 12 per cent, valued at $1,149,336, or 43 per cent of the total market value of the gas consumed, was distributed to 32,257 domestic consumers at an average price of 29.54 cents a thousand, the remaining 88 per cent of the volume, representing 57 per cent of the total market value, being distributed to 679 industrial consumers at an

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average price of 5.36 cents a thousand. Compared with statistics of the consumption of Louisiana gas in 1915, these data show in 1916 gain of 7 per cent in the number of consumers, of 2 per cent in the volume, of 11 per cent in the market value, and of 2.67 cents, or 10 per cent, in the average price per thousand feet of gas supplied to domestic consumers, and gain of 14 per cent in the number of consumers, of 30 per cent in the volume, of 33 per cent in the market value, and of 0.14 cent, or 2 per cent, in the average unit price of gas distributed to industrial consumers.

On the assumption that an average of 31,200 domestic consumers were supplied with Louisiana gas each month in 1916, the average monthly consumption of each consumer in that year was 10,400 cubic feet, and the average monthly cost of natural-gas service to each domestic consumer was $1.96.

No material changes were made in 1916 in the natural-gas distributing systems in Louisiana, as outlined in the report of this series for 1915.

Record of natural-gas industry in Louisiana, 1909–1916.

Year.	Number of producers.	Number of consumers.		Total value of gas produced.	Wells.		
		Domestic.	Industrial.		Drilled.		Productive Dec. 31.
					Gas.	Dry.	
1909	11	4,034	164	[a] $326,245	26	10	85
1910	21	8,547	320	[a] 509,408	23	4	97
1911	27	[b] 17,964	442	[a] 858,145	36	18	119
1912	41	[b] 24,087	474	[a] 1,747,379	50	20	150
1913	57	[b] 26,424	550	[a] 2,119,948	53	24	111
1914	54	[b] 29,751	618	[a] 2,227,999	52	26	239
1915	57	[b] 30,144	597	2,163,934	35	10	253
1916	73	[b] 32,257	679	2,660,445	48	47	263

[a] Includes the production of Alabama.
[b] Includes consumers supplied with gas piped from Louisiana to Arkansas and Texas.

Depth and rock pressure of wells in Louisiana, 1912–1916.

Parish.	Depth (feet).	Pressure (pounds).				
		1912	1913	1914	1915	1916
Bossier	800–2,463					300–1,000
Caddo	750–3,224	80–910	60–850	20–325	40–300	24–1,100
De Soto	746–905	400–450	350–450	338–716	[a] 466	100–260
Lafourche	80– 100	25	20	5– 10	15	
Morehouse	2,232–2,266					1,000–1,140
Natchitoches	1,010					20
Ouachita	1,200–3,240			Small.		1,060
Red River	904–2,668				[a] 400	100–950
Terrebonne	98– 126			50	34	18– 35

[a] New well.

TEXAS.

PRODUCTION.

The volume of natural gas produced and utilized in Texas in 1916 was greater than in any preceding year in the history of the natural-

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gas industry in the State. It amounted to 15,809,579,000 cubic feet, a gain of 2,485,832,000 cubic feet, or 19 per cent, over the volume produced in 1915, and was 18 per cent larger than the record yield of 13,433,639,000 cubic feet in 1914.

The market value of the output in 1916 was $3,143,871, a gain of $549,998, or 21 per cent, over the value of the output in 1915, and of $674,101, or 27 per cent, over the value of the output in 1914.

The average price at which Texas gas was sold in 1916 was 19.89 cents a thousand cubic feet, a gain of 0.42 cent, or about 2 per cent, over the average in 1915, and of 1.51 cents, or about 8 per cent, over the average in 1914.

The increase in the volume of natural gas produced in Texas in 1916 is accounted for principally by the extension of facilities for natural-gas consumption rather than by the development of strictly new sources of production. The principal contributor to the increased yield was the Strawn district in Palo Pinto County, which in 1916 furnished a large volume of natural gas to industrial plants and to a few domestic consumers at Thurber. Production of gas in the Mexia district, Limestone County, was materially increased in 1916 as a result of the extension of natural-gas service to a large number of domestic consumers in the city of Waco in that year. A part of the increase is ascribed also to the increased conservation of oil-field gas in the oil districts of north-central Texas as a consequence of the operation there of four plants for the manufacture of casing-head gasoline in 1916, compared with one plant in 1915.

The principal area of the commercial production of gas in Texas is the Petrolia oil and gas district, in Clay County, which supplies the gas consumed in Dallas and Fort Worth, as well as in a number of other cities and towns in north-central Texas. The drain on this field necessary to supply the needs of these communities had so diminished the pressure and volume of gas in 1916 that on September 30 the principal distributor of gas from the Petrolia field was compelled to forego the distribution of gas to industrial consumers in order that the supply remaining might be conserved for the benefit of domestic consumers. This action, though regrettable, is amply justified by the principles of true conservation, which require that natural resources shall be exploited on the basis of the greatest good to the greatest number. At the end of 1916 there were 56 gas wells in the Petrolia district, exclusive of a few wells that produced both gas and oil. Thirteen new gas wells were completed and 13 were abandoned in this field in 1916. The average closed pressure of the wells in the Petrolia field was about 175 pounds to the square inch at the end of 1916, a decline of 65 pounds during the year, against 90 pounds in 1915 and 180 pounds in 1914.

Second in importance as a source of natural gas in Texas is the Mexia-Groesbeck field, in Limestone County, which supplies the gas consumed in Waco and Corsicana, as well as in a number of towns in the immediate vicinity of the field. The volume of gas marketed from this field in 1916 was greater than in any other year since the field was discovered in 1912. Twelve gas wells were completed and 6 exhausted wells were abandoned in this field in 1916, and at the end of the year 53 gas wells were in service. The average closed pressure of these wells was 180 pounds to the square inch at the end of 1916, compared with 200 pounds at the end of 1915, 240 pounds at the end of 1914, 273 pounds at the end of 1913, and 275 pounds at the end of 1912.

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In the Moran oil and gas field in Shackelford County, which supplies the gas consumed in the towns of Moran, Baird, Clyde, Putnam, and Abilene, there were no important developments in 1916. North of the Moran district in Throckmorton County a gas well of small capacity was completed in March on the Matthews ranch, a short distance from a similar well drilled three years earlier.

The piping of natural gas to consumers in and near Thurber, Erath County, in 1916, directed attention to the source of that gas in the Strawn district, Palo Pinto County. This field, which lies about 2 miles southwest of Strawn, was discovered in 1914 by the Texas & Pacific Coal Co. in the course of test drilling to determine the position and thickness of a coal bed in that locality. With the discovery of petroleum to the north of the gas pool in 1915 little effort was made to utilize the gas for purposes other than drilling until 1916. At the end of 1916 there were about 50 wells with a combined capacity of perhaps 65,000,000 cubic feet of gas a day in this field. These wells range in depth from 900 to 1,800 feet and in closed pressure up to 650 pounds to the square inch. Many of them are capped, awaiting the provision of facilities for the marketing of their product.

A new gas field of considerable promise was opened in 1916 in the eastern part of Palo Pinto County. The initial well in this field was drilled near the end of 1915 on the Hess ranch, 5 miles south of Mineral Wells, and, after encountering gas in fair volume in a sand reached at a depth of 720 feet, was drilled deeper in quest of oil and ultimately lost by flooding in January, 1916. A second well a few hundred feet to the northeast, completed in February, 1916, was credited with an initial capacity of 3,000,000 cubic feet of gas from a sand found at a reported depth of 1,060 feet. The completion in March as a gas well of fair capacity of a test on the Edmonson ranch, 7 miles south of Mineral Wells, confirmed the discovery of an important gas field in this locality. Subsequent drilling proved the productivity of the territory between the Hess and the Edmonson wells and attracted to the district the Doherty interests, which acquired in July a controlling interest in the new field that assures its efficient development.

In Stephens County, west of Palo Pinto County, and in Parker County, east of it, gas in fair volume was found in wells considerably in advance of the Strawn district and of the Edmonson-Hess area.

No new development took place in the Bangs gas field, in Brown County, in 1916, three wells supplying the fuel needs of some 85 consumers in the town of Bangs.

In Coleman County tests drilled for oil between Santa Ana and the old Trickham gas field in the southeastern part of the county furnished encouragement to the further quest for oil in the locality and added materially to the supply of natural gas available for field use and for consumption in Santa Ana.

Wells in the Reiser gas field in Webb County supplied, as in previous years, the natural gas consumed in Laredo. During 1916 a pipe line was constructed by the Border Gas Co. from Laredo to the Jennings ranch gas field in northern Zapata County, 30 miles southeast of Laredo, and plans were completed for substituting gas from this source for that formerly obtained from the nearly exhausted Reiser field.

Six wells in the Crowther gas field, in McMullen County, supply natural gas to consumers in the town of Crowther. Ten other gas wells in this district are not in use.

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In the Corpus Christi district, on the north side of Nueces Bay, in San Patricio County, little substantial progress was made in the development of the enormous resources of gas already proved to exist. On December 31, 1915, a gas well, the initial capacity of which was estimated in excess of 100,000,000 cubic feet of gas a day, blew itself in on the White Point lease of the Gulf Production Co., about 800 feet north of a similar well drilled in 1914. This well was completed the first week of January, 1916, but broke its heavy fittings on January 12 and ran wild for several days. On January 17 it caught fire and for nearly two months burned fiercely, forming about its mouth, as in the case of its predecessor, a seething crater of water, mud, and burning gas that engulfed the remnants of the drilling rig and eventually choked the hole. The third well on this lease came in on July 16 with an estimated initial capacity of 20,000,000 cubic feet of gas a day, under a rock pressure of 600 pounds to the square inch. After blowing gas for several days this well was capped, and when opened later in July was found to have gone to salt water, barely enough gas being available for additional drilling in the locality. After running wild for more than a year well No. 1, of the Gulf Coast Oil & Gas Co., on the Kirk tract, 2 miles east of the White Point wells, was finally brought under control and capped in December, 1916. Although a franchise was sought for supplying the gas from this well to the town of Corpus Christi, no active steps were taken toward marketing its product in 1916.

In practically all the oil fields in Texas more or less gas is used for drilling and pumping operations, and in various localities in the State scattered wells, some of which are essentially water wells, furnish enough gas to satisfy the domestic requirements of one or more families each.

At the end of 1916 there were 257 gas wells in service in Texas, a net gain of 43 wells, or 20 per cent over the number in service at the end of 1915.

CONSUMPTION.

Aside from the natural gas piped into Texas from Louisiana for consumption in half a dozen towns adjacent to the State boundary, which is accounted for in the statistics for Louisiana, the volume of natural gas consumed in Texas in 1916 was equivalent to the volume produced, as no gas was piped from Texas to other States in that year.

Of the natural gas from intrastate sources consumed in Texas in 1916, some 5,423,295,000 cubic feet, or about 34 per cent, valued at $2,112,893, or 79 per cent of the total market value, was distributed to 68,218 domestic consumers at an average price of 38.96 cents per thousand cubic feet.

Compared with the statistics of natural-gas consumption for domestic purposes in Texas in 1915 these data show gain in 1916 of 15 per cent in the number of consumers favored with natural-gas service, of 10 per cent in the volume of gas consumed, of 14 per cent in the market value of the gas, and of 1.24 cents, or 3 per cent, in the unit price at which the gas was sold.

On the assumption that an average of 63,802 domestic consumers were supplied throughout the entire year, the average volume of gas consumed monthly by each consumer was about 7,100 cubic feet and

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the average monthly cost of natural-gas service to each consumer was about $2.76.

The remaining 66 per cent of the Texas gas consumed in 1916, representing 21 per cent of the total market value, was distributed to 931 industrial consumers at an average price of 9.93 cents a thousand.

Compared with the statistics of natural-gas consumption for industrial purposes in Texas in 1915, these data show gain in 1916 of 35 per cent in the number of consumers, of 24 per cent in volume of gas consumed, of 40 per cent in the market value of the gas, and of 1.17 cents, or 13 per cent, in the average unit price at which the gas was sold.

Record of natural-gas industry in Texas, 1909-1916.

Year.	Number of producers.	Number of consumers.		Total value of gas produced.	Wells.		
		Domestic.	Industrial.		Drilled.		Productive Dec. 31.
					Gas.	Dry.	
1909	17	5,035	130	$127,008	7	6	38
1910	19	14,719	133	447,275	22	5	52
1911	29	22,972	303	1,014,945	19	14	69
1912	41	27,226	329	1,405,077	24	23	87
1913	50	37,350	393	2,073,823	43	29	126
1914	75	48,547	468	2,469,770	89	23	197
1915	65	59,386	677	2,593,873	27	30	214
1916	83	68,218	931	3,143,871	77	113	257

IOWA.

The production of natural gas in Iowa in 1916 came from 4 shallow wells in Louise County, where sufficient gas was obtained from deposits of glacial drift for lighting three dwellings. Two additional wells in the same county were not in use during the year. The discovery of gas in fair volume in a well drilled on the farm of Antone Leber, near Herndon, Guthrie County, resulted in the formation of the Interstate Gas & Oil Co., at Herndon, to prospect thoroughly the territory adjacent to that town. Although leases on considerable acreage were obtained, no wells were completed in 1916.

NORTH DAKOTA.

The natural-gas situation in North Dakota was essentially unchanged in 1916. Aside from gas obtained from wells in Bottineau County and distributed commercially in the town of Lansford, the gas produced in North Dakota in 1916 was obtained from scattered wells in Bottineau, Lamoure, and Renville counties, which supply only enough gas for the domestic needs of two or three families each.

At the end of 1916 there were 13 wells in North Dakota from which gas was being utilized.

SOUTH DAKOTA.

The natural gas produced and utilized in South Dakota accompanies artesian water in wells ranging from 1,250 to 2,040 feet in depth in Corson, Hughes, Potter, Stanley, Sully, and Walworth counties. Aside from Pierre and Fort Pierre, where the gas from 5 wells was

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distributed to some 365 domestic and 3 industrial consumers, the consumption of natural gas in South Dakota in 1916 was restricted to isolated households which derived their supplies from individual wells.

MONTANA.

PRODUCTION AND CONSUMPTION.

Decided progress was made in 1916 in the development and utilization of the natural-gas resources of Montana. In that year natural-gas service was provided for 615 domestic and 3 industrial consumers in the municipality of Havre, Hill County, by the Havre Natural Gas Co., and for 112 domestic and 1 industrial consumer in Glendive, Dawson County, by the Eastern Montana Oil & Gas Co. The supply of gas distributed in Havre was obtained from 3 wells, 1 of which was drilled in 1916, located in or near that town. That distributed in Glendive was obtained from 5 wells, 2 of which were completed in 1916, near the mouth of Cedar Creek about 10 miles southwest of Glendive. In the Havre district 1 additional gas well, the product of which was not used in 1916, was completed during the year by the Havre Oil & Gas Co. Wells in this district range in depth from 935 to 1,250 feet. At the end of 1916 the average closed pressure of the gas was about 400 pounds to the square inch, compared with about 540 pounds at the end of 1915.

In the Cedar Creek district, Dawson County, gas under pressure of 200 pounds to the square inch is obtained from wells less than 900 feet deep, located on the Glendive anticline. This low fold extends from Yellowstone River southeast across eastern Montana and southwestern North Dakota into the extreme northwest corner of South Dakota and in the last two years has received considerable attention from oil and gas prospectors. That it is productive of gas at points other than in the Cedar Creek district at its north end was proved in 1916 by discoveries of gas in a test well drilled by the Treasure State Oil & Gas Co., 20 miles northwest of Baker, Fallon County, and in two wells drilled at Baker by the Montana Petroleum Co., which company obtained a franchise to supply the municipality of Baker with gas and near the end of 1916 began the distribution of gas to consumers in that town.

Natural gas in sufficient volume to supply the domestic needs of one family is obtained from a well on the ranch of Charles M. Bair, near Hardin, Big Horn County, in the Crow Indian Reservation.

The volume of gas marketed from wells in Montana in 1916 is estimated at 213,315,000 cubic feet, valued at $38,855, an average price of 18.21 cents a thousand cubic feet. At the end of 1916 there were 13 gas wells in Montana, 11 of which were in service.

WYOMING.

PRODUCTION AND CONSUMPTION.

The year 1916 was one of substantial progress in the natural-gas industry of Wyoming, the profitable production of gas in that year being greater by 83 per cent than in 1915. This increase is ascribed in part to a moderate gain in the volume of gas consumed in the municipalities of Basin, Greybull, and Byron, in Big Horn County,

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which have been favored with natural-gas service for a number of years, in part to an extension of natural-gas service to some 160 consumers in the town of Lovell, also in Big Horn County, and in part to a large gain in the volume of gas utilized for drilling and pumping operations in the oil fields of the State.

The gas supplied to Lovell is obtained from wells in the Byron district, 9 miles southwest of that town, and is distributed by the Lovell Gas & Electric Co., a corporation chartered in 1916 to furnish gas and electric service to a number of towns in Big Horn County. The volume of gas supplied from the Byron district to consumers in Byron and Lovell represents but a fraction of the volume available in that district. Although seriously considered in the latter part of 1915, the project for piping gas from this field to Billings was abandoned in 1916.

Additional evidence of vast reserves of natural gas in areas remote from existing markets on the west side of the Big Horn Basin was provided in 1916 by the completion in September as a gas well credited with an initial capacity of 3,000,000 cubic feet a day of a wildcat test drilled on the rim of Oregon Basin in southern Park County.

In the east-central part of Park County gas in volume considerably in excess of that required for drilling purposes was encountered in wells drilled by the Mountain States Oil Co., near Cody.

In the northeastern part of Park County a gas field of considerably prospective value was opened in 1916 near Frannie. The discovery well, the only one drilled in the field during the year, was completed in June by the Lamb Drilling Co., in sec. 27, T. 57 N., R. 98 W. sixth principal meridian, and was credited with an initial capacity of 7,000,000 cubic feet of gas a day. It is on a structure known as the Mantau dome and is about 10 miles southwest of Frannie. The well was capped, and to the end of 1916 no market had been found for its product.

A total of 749 domestic and 13 industrial consumers were supplied with natural gas in Wyoming in 1916, compared with 599 domestic and 10 industrial consumers in 1915.

Statistics of the volume and market value of natural gas produced in Wyoming are combined with those of gas produced in Colorado in order to avoid the disclosure of data furnished in confidence by individual producers.

COLORADO.

Aside from a small volume of gas obtained from oil wells and used locally in the Boulder and Florence oil fields the natural gas produced profitably in Colorado in 1916 came from individual wells that furnish only enough gas for the domestic needs of one to three families each. Of these wells 1 is in Alamosa County, 1 in Saguache County, 2 in Las Animas County, and 2 in Mesa County.

Gas from the "spouter well" on the Myers ranch near De Beque, Mesa County, was utilized in 1916 as fuel for the drilling of a second well on this property, by the Rifle-De Beque Oil & Gas Co. The second well, which is located 400 feet east of the "spouter," was not completed in 1916. Although the matter of piping gas to De Beque from the Myers property and from a gas well controlled by the Grand River Oil & Gas Co. on the Dudley ranch was considerably agitated, no direct steps to this end were taken in 1916.

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Gas flows, insufficient for commercial utilization, are reported from a number of artesian water wells in the San Luis Basin in Alamosa and Saguache counties.

OREGON.

Despite the occurrence of natural gas in a number of localities in Oregon, reports submitted to the Geological Survey fail to indicate its utilization in this State in 1916 outside Malheur County, where two establishments near Ontario were supplied with natural gas from a well drilled for oil several years ago.

WASHINGTON.

As far as can be ascertained from reports submitted to the Geological Survey, the production of natural gas in Washington in 1916 was restricted to Benton County, where gas from one well was used as fuel for drilling on adjacent properties.

CALIFORNIA.

PRODUCTION.

The steady expansion that has characterized the trend of the natural-gas industry in California in recent years was continued in 1916. It is estimated that 31,643,266,000 cubic feet of natural gas was produced and utilized in this State in 1916. This volume, which is greater than that produced profitably in California in any preceding year, exceeded the volume produced in 1915 by 9,752,231,000 cubic feet, or 44 per cent.

The market value of this gas was $5,440,277, and the average price at which it was sold was 17.19 cents a thousand cubic feet, a gain of $1,371,273 cubic feet, or 34 per cent, in total market value, despite a loss of 1.4 cents, or 7 per cent, in unit selling price, compared with 1915.

As the potential supply of natural gas in California is far in excess of existing marketing facilities, statistics of gas produced in this State reflect merely the ability of the gas-distributing companies to supply the demand. Material gains in gas production in California in recent years have resulted not only from annual extensions of gas-distributing systems, but from a rapid increase in the utilization of natural gas for the manufacture of gasoline.

The greater part of the natural gas produced in California in 1916 came, as in previous years, from the Midway district, in Kern County, in which gas flows of large volume are obtained from wells along the Buena Vista Hills anticline. In this field the wells range in depth from 2,100 feet to 3,000 feet, and closed pressures average about 300 pounds to the square inch. Gas from this source is extensively used as fuel for drilling and pumping in the adjacent oil fields and as fuel and light in several towns in the Midway and Sunset districts. It is piped eastward across San Joaquin Valley to Bakersfield and to the Kern River oil field, a distance of about 40 miles, and is also piped southward across the Tehachapi and Santa Susana mountains to Glendale, a distance of 107 miles, and from there distributed to a score of cities and towns in southern California.

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Second in rank as a contributor to the natural-gas supply in California is the Whittier-Fullerton district, in Orange and Los Angeles counties. From the Coyote Hills and Brea Canyon fields in this district natural gas is distributed to many towns in southern Los Angeles, western Riverside, and Orange counties. The greater part of the gas produced in these fields is obtained from wells that also produce oil, the volume of gas conserved representing, however, only a fraction of the total volume available.

In the Santa Maria district, in Santa Barbara County, natural gas is obtained from oil wells in sufficient volume to satisfy fuel needs in the oil fields, to support a thriving casing-head gasoline industry, and to supply some 2,700 domestic and industrial consumers in Santa Maria, Betteravia, Guadalupe, Nipomo, Arroyo Grande, Orcutt, San Luis Obispo, Pismo Beach, and Avila, natural-gas service having been extended during 1916 to residents of the last three municipalities named. Natural gas from a few old oil wells in the Summerland field in the southeastern corner of Santa Barbara County is supplied to consumers in Summerland.

Oil wells in the several fields of the Santa Clara River valley, in Ventura County, supply natural gas for field operations, for gasoline manufacture, and for mixing with artificial gas to supply consumers in Ventura, Santa Paula, and Oxnard.

In Kings County numerous water wells ranging in depth from 300 to 2,300 feet yield sufficient gas with the water to provide light and, in some instances, fuel for one or more residences each. No less than 28 families were supplied with gas from 39 wells of this type in Kings County in 1916.

Natural gas that accompanies water in many wells in San Joaquin and Sacramento counties is collected and distributed to more than 15,000 domestic consumers in Sacramento, Stockton, and Lodi.

In Santa Clara County gas from oil wells in the Sargent Ranch field and in the Moody's Gulch field is utilized for field operations in these districts.

In Solano County one well drilled in 1901 at Fairfield yields sufficient gas to supply the needs of domestic and industrial consumers in Fairfield, Suisun, and Cement.

In Tehama County sufficient gas is obtained from one well at Tuscan Springs to supply the needs of a hotel at that place.

In Humboldt County one well at Briceland, drilled more than 20 years ago for oil, produces enough natural gas to supply a few domestic consumers in Briceland.

At the end of 1916 there were 87 producers of natural gas in California, compared with 59 at the end of 1915. Exclusive of wells that produce both petroleum and natural gas, there were 105 productive gas wells in California at the end of 1916, compared with 108 at the beginning of that year, 7 new gas wells having been drilled and 10 exhausted wells abandoned during the year.

CONSUMPTION.

As no gas is piped into or from California, the gas consumed in this State in 1916 is equivalent in volume and value to the gas profitably produced in that year.

Of the volume consumed in 1916, about 5,629,022,000 cubic feet, or 18 per cent, valued at $3,598,695, or 66 per cent of the total

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market value, was distributed to some 242,775 domestic consumers at an average price of 63.93 cents a thousand cubic feet, the remaining 82 per cent of the gas consumed, accounting for 34 per cent of the entire market value, being distributed to 175 industrial consumers, including manufacturers of casing-head gasoline, at an average price of 7.08 cents a thousand cubic feet.

Compared with the statistics of natural gas consumed for domestic purposes in California in 1915, these data show gain in 1916 of 17 per cent in the number of consumers, of 34 per cent in the volume of gas consumed, and of 28 per cent in the market value of that gas, despite a decrease of 2.77 cents, or 4 per cent, in the unit price paid for it.

An average of 225,224 consumers in California were supplied with natural gas each month in 1916, the volume of gas consumed monthly by each consumer was 2,100 cubic feet, and the average monthly cost of natural-gas service to each consumer was $1.34.

Compared with statistics of natural-gas consumption for industrial purposes in California in 1915, these data show in 1916 decrease of 32 per cent in the number of consumers and of 0.05 cent in the average price per thousand paid for gas, but gain of 47 per cent in the volume of gas consumed and of 46 per cent in the total market value of that gas. The large increase in the consumption of gas for industrial purposes in 1916 is accounted for by the large increase in the volume of gas utilized for the manufacture of casing-head gasoline in that year, statistics of which are presented on subsequent pages of this chapter.

The only changes of importance in the list of gas-distributing companies in California given in the report of this series for 1915 include the addition of the name of the Midland Counties Public Service Corporation, which in 1916 began the distribution of natural gas from the Santa Maria district to the municipalities of San Luis Obispo, Pismo, and Avila, and the substitution of the name of the Valley Natural Gas Co. for that of the California Natural Gas Co. as the wholesale distributor of the natural gas consumed in Bakersfield, Maricopa, and Taft, the former company having taken over the properties of the latter by purchase on June 15, 1916.

Record of natural-gas industry in California, 1909–1916.

Year.	Number of producers.	Number of consumers.		Total value of gas produced.	Wells.		
		Domestic.	Industrial.		Drilled.		Productive Dec. 31.
					Gas.	Dry.	
1909	35	7,612	104	$446,933	7	.....	[a] 64
1910	30	8,292	217	476,697	3	2	[a] 65
1911	32	10,508	307	800,714	3	6	[a] 66
1912	43	18,171	232	1,134,456	6	1	[a] 71
1913	48	[b] 164,358	141	1,883,450	9	4	[a] 72
1914	57	[b] 205,163	172	2,910,784	8	1	[a] 75
1915	59	[b] 207,673	257	4,069,004	2	2	[a] 108
1916	87	[b] 242,775	175	5,440,277	7	.....	[a] 105

[a] Includes some artesian wells from which gas was used.
[b] Includes some consumers who are using mixed gas.

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NATURAL GAS IN FOREIGN COUNTRIES.

CANADA.

The preliminary report on the mineral production of Canada in 1916, issued by the Canada Department of Mines, Mines Branch, contains the following summary of natural-gas production in Canada:

The total production of natural gas, according to returns received, was 25,238,568 thousand cubic feet, valued at $3,924,632, as compared with a production in 1915 of 20,124,162 thousand cubic feet, valued at $3,706,035. The production by Provinces was as follows: Ontario, 17,838,318 thousand cubic feet, valued at $2,730,653; New Brunswick, 610,118 thousand cubic feet, valued at $79,628; and Alberta, 6,818,131 thousand cubic feet, valued at $1,114,351.

The following data concerning the quest for natural gas in the Province of Quebec are contained in a report by Consul W. R. Dorsey for the year 1916:

Concerning natural gas it is remarked in the annual report of the Department of Mines that very little has taken place in the St. Hyacinthe County field since the last report, and what was done does not seem to bear out the rather sanguine expectations of the operators. The fourth well of the Canadian Natural Gas Co., which had reached a depth of 2,450 feet in December, 1915, was stopped and had not been resumed in January, 1917. The natural gas has not yet been demonstrated in this field, and for a conclusive test a well would have to be put down to the Trenton formation, which is here overlain by more than 3,455 feet of shales, in which exist pockets of gas.

Value of natural gas produced in Canada, 1909–1916.

Year.	New Brunswick.	Alberta.	Ontario.	Total Canada.
1909	.....	$61,722	$1,145,307	$1,207,029
1910	.....	75,168	1,271,303	1,346,471
1911	.....	110,165	1,807,513	1,917,678
1912	$36,549	289,906	2,036,245	2,362,700
1913	174,147	1,079,466	2,055,768	3,309,381
1914	54,249	1,214,670	2,215,808	3,484,727
1915	60,383	1,022,814	2,622,838	3,706,035
1916	79,628	1,114,351	2,730,653	3,924,632

The following table showing data concerning the natural-gas industry in the Province of Ontario is presented through the courtesy of Thos. W. Gibson, Deputy Minister of Mines, Toronto, Ontario:

Statistics of natural gas in the Province of Ontario, Canada, 1909–1916.

Year.	Wells bored in the year.		Producing wells, Dec. 31.	Miles of gas pipe.	Workmen employed.	Gas produced.		Wages for labor.
	Productive.	Nonproductive.				Quantity (cubic feet).	Value.	
1909	.....	.....	744	987	171	5,388,000,000	$1,145,307	$103,672
1910	.....	.....	828	982	186	7,263,427,000	1,271,303	118,786
1911	268	38	1,179	1,296	287	10,863,871,090	1,807,513	182,663
1912	178	41	1,247	1,448	277	12,529,463,000	2,036,245	184,351
1913	211	49	1,605	1,720	336	12,474,745,000	2,055,768	237,600
1914	120	28	1,665	1,380	392	14,094,521,000	2,215,808	224,492
1915	109	18	1,734	1,931	598	15,211,523,000	2,622,838	382,401
1916	185	38	1,802	2,233	653	17,838,318,000	2,730,653	404,039

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ITALY.

The following statistics of the natural-gas industry in Italy are quoted from the Rivista del Servizio minerario:

Natural gas produced in Italy, 1909–1916.

Year.	Quantity (cubic meters).	Value.	Year.	Quantity (cubic meters).	Value.
1909	8,268,000	$42,287	1913	6,015,000	$48,974
1910	8,840,000	73,301	1914	5,920,000	48,479
1911	9,021,000	74,174	1915	5,812,000	71,381
1912	6,800,000	57,128	1916	(a)	(a)

a Not available.

Of the total volume of gas produced in Italy in 1915, the Province of Parma contributed 1,112,000 cubic meters and the Province of Piacenza 4,700,000 cubic meters.

That the shortage of fuel in Italy has caused efforts toward the further development of the natural-gas resources of this country is indicated by the following article on natural-gas lighting at Pisa, translated from La Métallurgie (Paris), issue of October 31, 1917:

For some years past a farm in the Commune of Agnans, about 3 kilometers from Pisa, has been lighted by natural gas discovered by the owner while boring for potable water. The present shortage of coal has naturally called attention to this unexplored source of fuel supply, and after preliminary investigations it has been decided to supply the city of Pisa with natural gas. This gas, which has a heating power of about 9,000 calories per cubic meter, is sent through pipes under a pressure of 1 to 1½ atmospheres and is supplied to consumers in Pisa at a price which permits a daily saving of about 400 lire ($77.20) without taking into account the steady increase in the price of coal and the difficulties of obtaining it.

UNITED KINGDOM.

The production of natural gas in Great Britain is restricted to a single locality in Sussex County, England. The following statistics of the output from this source are quoted from the annual report of the British Home Office:

Natural gas produced at Heathfield, Sussex County, England, 1909–1916.

Year.	Quantity (cubic feet).	Value.	Year.	Quantity (cubic feet).	Value.
1909	236,800	(a)	1913	87,450	(a)
1910	262,000	(a)	1914	87,000	(a)
1911	221,400	(a)	1915	87,000	(a)
1912	161,200	(a)	1916	(a)	(b)

a Not stated. b Not available.

HUNGARY.

Progress in the development of the natural-gas resources of the Kis-Sármás district in Transylvania is recorded in the annual report of the Hungarian General Credit Bank of Budapest for 1916, from which report the following passages have been translated:

Our efforts to turn to useful purpose the natural-gas resources of Transylvania met with some success last year, as the Deutsche Bank, with the cooperation of local

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banks and of others interested in the venture formed in June, 1916, the Hungarian Natural Gas Co., capitalized at 27,000,000 crowns (about $5,625,000), a part of which was duly taken up by this institution. At the same time the new Hungarian Nitrate Manure Co. was organized by this bank in cooperation with the Budapest Hungarian Commercial Bank and other Hungarian and German interests and held its first general meeting. This company, which is capitalized at 9,000,000 crowns (about $1,875,000), is erecting at Dieso-Szt-Marton a plant for the manufacture of nitrated lime and other chemical products, making use, for this purpose, of natural gas from Transylvanian sources. The erection of buildings is now (April, 1917) nearing completion and the plant is expected to start work in the near future. The purpose of the enterprise is primarily to serve military needs, but at the same time nitrate manure for agricultural purposes will be manufactured, so that with the return of peace the company may be in a position to contribute materially to the solution of weighty problems of agriculture now awaiting attention.

Subsequent information [1] is to the effect that the Hungarian Natural Gas Co. had in contemplation the erection of a plant for the recovery of aluminum from deposits of bauxite near its gas fields in Transylvania.

Additional information concerning the increased utilization of natural gas in Hungary is contained in the following news item from The Electrician (London), August 17, 1917:

Our contemporary, Engineering, reports that the town of Torda in Hungary, where the exploitation of natural gas has assumed large proportions, has installed a system of heating by natural gas for domestic and industrial purposes. The price of gas for factories and industrial purposes is stated to be 1 heller ($0.002 normal exchange) per cubic meter. The Hungarian State Railways are illuminated with this gas, and, as the supply exceeds the local requirements, plans are under consideration for delivering it to Budapest (a distance of about 300 miles). A large electric generating station for the production of atmospheric nitrates, with a capacity of 20,000 horsepower, and a large aluminum works are projected, and in connection with both these schemes test installations have been erected.

Information as to the output of natural gas in Hungary in 1916 is not available, but the output in 1915 is reported to have been 25,108,054 cubic meters, valued at 45,664 crowns ($9,270, at normal rates of exchange).

DUTCH EAST INDIES.

Statistics furnished by the Hoofdbureau van het Mijwezen, Batavia, Java, credit the Dutch East Indies with a production of 91,121.2 metric tons of natural gas in 1916. This production was distributed as follows: Java, 24,371.3 metric tons; Sumatra, 66,122.8 metric tons; Borneo, 627.1 metric tons.

JAPAN.

According to the Petroleum Times of Tokio there were in September, 1917, nine plants for the extraction of gasoline from natural gas in operation in the Nishiyama field, Echigo. Five of these, having an average daily capacity of 5,000 gallons, are operated by the Nippon Oil Co.; 3, having a combined daily output of 3,000 gallons, by the Hohden Oil Co.; and 1, with a daily capacity of 500 gallons, by the Ogura Oil Co. The Nippon Oil Co. is reported to contemplate the installation of three additional plants in the near future.

[1] Ironmonger (London), Sept. 15, 1917.

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GASOLINE FROM NATURAL GAS.

GENERAL STATEMENT.

The history of the natural-gas gasoline industry in the United States is the history of one of the most effective movements in the direction of true conservation of natural gas that has ever been undertaken in this country. Although the foundations of this industry were laid in 1903 and 1904, the period of its greatest expansion is included in the seven years since 1909. In 1911, the first year for which statistics on the subject are available, 176 plants in 9 States produced 7,425,839 gallons of raw gasoline from natural gas. In 1916, only five years later, 596 plants in 12 States produced 103,492,689 gallons, a gain in this remarkably brief period of nearly 239 per cent in the number of plants and of nearly 1,294 per cent in the annual output of raw gasoline. The volume of natural gas treated in the production of the output of gasoline in 1911 was only 0.5 per cent of the volume of gas produced and utilized in the entire country in that year. The volume treated in 1916 represents 27.7 per cent of the volume produced and utilized in that year and is greater by 8,330 per cent than the volume treated in 1911. The fact that the output of gasoline from natural gas has increased in the last five years more rapidly than the number of plants is evidence that the trend of the industry has been toward the erection of plants of larger individual capacity than were at first considered feasible. The fact that the volume of gas treated annually has increased in the same period at a rate far greater than that of the raw gasoline produced emphasizes the trend of the industry toward the successful utilization of gas leaner in its content of gasoline vapors than was believed possible in the early days of the industry. The trend in the latter direction has been most pronounced in the last two years as a consequence of the development of the absorption process, which renders feasible the treatment of gas containing as low as 1 pint of gasoline to the thousand cubic feet.

Prior to 1916 the greater proportion of the gasoline produced from natural gas was obtained from casing-head gas, oil-well gas, or "wet" natural gas by the compression and condensation method, which, however, is restricted in its profitable application to gas that contains not less than 1 gallon of gasoline to the 1,000 cubic feet. The development of the absorption process has extended the field of the natural-gas gasoline industry to include practically all the natural gas produced in the United States, for there is but little gas produced in this country that does not contain appreciable percentages of pentane and hexane, the hydrocarbons of the paraffin series that are the principal constituents of gasoline. Much of the so-called "dry" gas obtained from oil wells when they are first opened and from gas wells that produce no petroleum has been found sufficiently rich in gasoline vapors to warrant treatment by the absorption process, though excluded from successful treatment by compression and condensation.

The absorption method has been described in detail elsewhere.[1] It consists essentially in bringing natural gas into intimate contact

[1] Burrell, G. A., Biddison, P. M., and Oberfell, G. G., Extraction of gasoline from natural gas by absorption methods: Bur. Mines Bull. 120, 1917.

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with an oil heavier than gasoline, letting the oil absorb the gasoline from the gas and then separating the absorbed gasoline from the oil by ordinary fractional distillation, or in passing natural gas through naphtha having a gravity of 50° to 55° Baumé and allowing the naphtha to absorb a sufficient proportion of the high-gravity gasoline to increase the gravity of the resulting mixture to a point that will bring it within the realm of commercial gasoline.

The first large installation for the manufacture of gasoline from natural gas by absorption methods is believed to have been that of the Hope Natural Gas Co., at Hastings, W. Va., in 1913. In 1916, the first year for which complete statistics on the subject are available, there were 46 absorption plants in 8 States, 14 of which plants were in West Virginia alone. Including the gasoline recovered as drips from natural gas mains in these States the quantity of gasoline recovered by absorption methods in 1916 was about 18,569,902 gallons, or 18 per cent, of the total quantity obtained from natural gas in that year.

Although the total quantity of gasoline produced from natural gas constitutes only about 5.0 per cent of the estimated total of 2,261,815,527 gallons of internal-combustion engine fuel produced in the United States in 1916, it represents a contribution to the gasoline supply of the country of far greater importance than its statistical position would indicate. On the one hand, it represents the production of a type of gasoline that will fulfill the rigid requirements of motor fuel for airplanes assigned to high-altitude duty, and also a type of high-gravity material that will blend with low-gravity naphthas to produce a desirable fuel for ordinary motors; on the other hand, the production of natural-gas gasoline represents true conservation in that it has brought about the saving of a great volume of oil-well gas, or casing-head gas, that was formerly allowed to waste, because the volume obtainable from individual wells was not sufficient to warrant the expense of collecting and piping it to market.

As gas of this type is generally the richest in gasoline vapors, the cost of saving it is no longer a prohibitive factor, and once collected and treated, the residual gas becomes available for augmenting the supply distributed to domestic and industrial consumers. Not only has the development of the casing-head gasoline industry resulted in a material increase in the volume of gas available for consumption, but in many localities it has resulted in an appreciable gain in the quality and heating power of the gas supplied to consumers. Casing-head gas is notably rich in heating value, often as high as 2,000 to 2,500 British thermal units per cubic foot. Although the removal of the gasoline vapors lowers its fuel value slightly, the residual gas is generally far superior in heating value to the so-called "dry" gas distributed to most communities. The addition of exhaust gas from casing-head gasoline plants to the "dry" gas or "gas-well" gas formerly distributed to consumers in the Pittsburgh district in western Pennsylvania, has unquestionably increased materially the average fuel value of the gas distributed in that district in the last three years.

The development of the absorption process for the treatment of "dry" gas has also resulted in material benefits to the consumers

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of natural gas despite a rather widespread opinion to the contrary among such consumers of this utility as have not learned to differentiate between low pressure on gas mains and deficient heating value. Careful tests have shown that the average loss in heating value of "dry" natural gas, as a consequence of its passage through an absorption plant, is about 2 per cent. This means for natural gas containing 1,200 British thermal units per cubic foot a loss of about 24 heat units—a loss too small for detection in any type of burner ordinarily employed for the domestic or industrial consumption of gas.

The positive benefits provided the consumer are in the form of improved service made possible by the drying effect on the gas of the absorption process. The principal foes to reliable natural-gas service are gasoline vapor, which destroys the rubber couplings in gas mains and permits leakage, and water vapor, which in cold weather condenses and freezes in the mains and retards or entirely prevents the passage of the gas. The elimination of these factors has been for many years a serious problem to the natural-gas industry and especially to companies that transport natural gas long distances. To rid the mains of these condensates drip valves were formerly installed at low points on all gas lines of consequence, and the "drips" were blown out frequently by the simple expedient of opening the valves and permitting the pressure of the gas in the line to force the accumulated liquids into the air. By this means the gasoline and, in the aggregate, a considerable volume of gas, were absolutely lost. The advent of the absorption process has provided a means for preventing these losses. By the installation of absorption plants on gas transmission lines the gasoline vapors are all removed at one place, without loss of gas, and the gasoline is made available for satisfying the ever-increasing demand for motor fuel. Incidentally the absorption process removes a considerable proportion of the water vapor from the gas and consequently reduces to a minimum the possibilities of line troubles due to freezing.

MARKETED PRODUCTION.

The steady annual increase in production of gasoline that has characterized the growth of the natural-gas gasoline industry in the United States during the last six years was fully maintained in 1916. The quantity of raw gasoline obtained from natural gas—including that produced by the compression and absorption methods, that obtained by the use of vacuum pumps, and that recovered as drips from gas-transmission lines—and sold in 1916, was 103,492,689 gallons, a gain of 38,128,024 gallons, or 58 per cent, over the output of 1915. The quantity of commercial gasoline represented by this output of raw material, though not susceptible of accurate determination because of the extreme variation in blending practice, is estimated roughly at 200,000,000 gallons.

Of the total quantity of raw gasoline produced from natural gas in 1916, it is estimated that 84,922,787 gallons, or 82 per cent, was produced by compression methods or obtained by the use of vacuum pumps, and that the remaining 18 per cent was produced by absorption methods or recovered as drips from gas-transmission lines.

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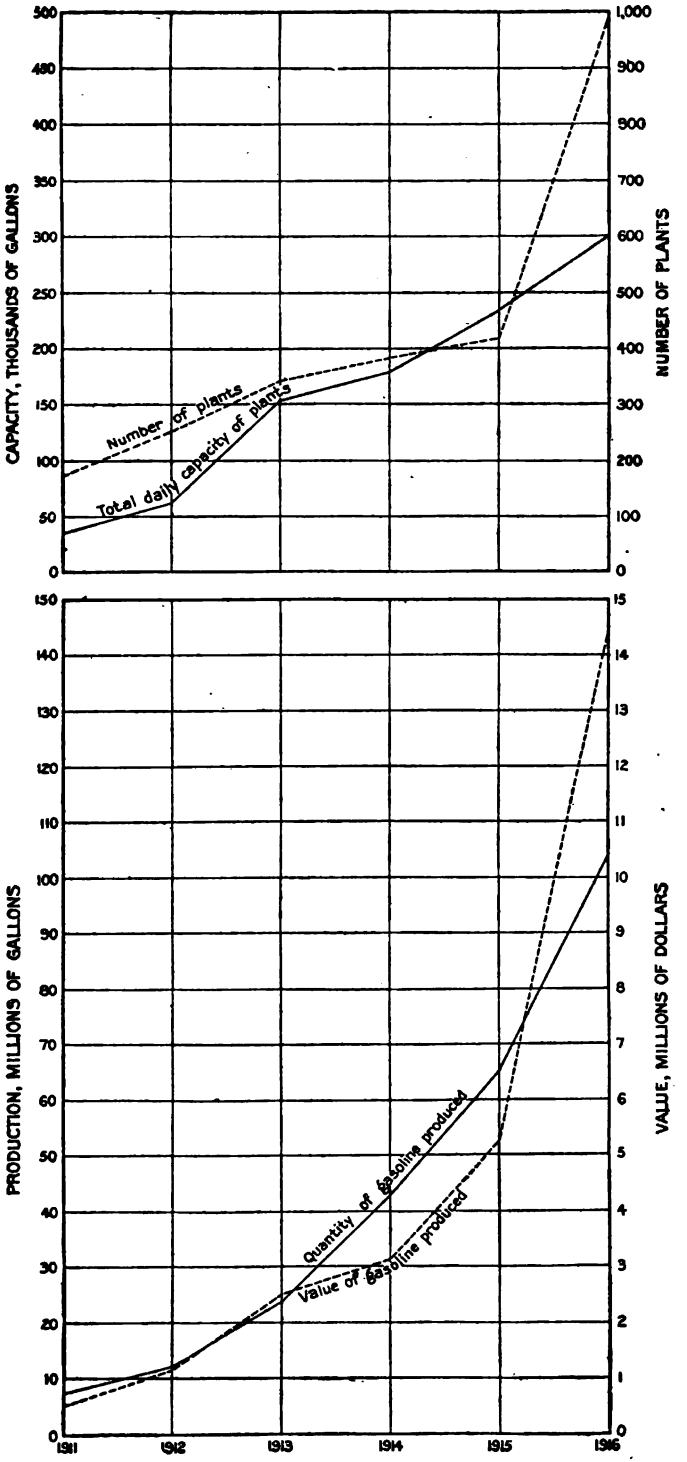

FIGURE 16.—Number and capacity of plants producing gasoline from natural gas and quantity and value of gasoline produced from natural gas in the United States, 1911–1916.

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The average price received in 1916 for the unblended product at the sources of production was 13.85 cents a gallon and the market value of the entire output was $14,331,148, a gain of 5.97 cents in average unit selling price and of $9,180,325, or 178 per cent, in the total value compared with 1915.

The volume of natural gas from which this quantity of gasoline was recovered is estimated at 208,705,023,000 cubic feet, the average recovery of gasoline per thousand cubic feet being about half a gallon.

The number of plants for the manufacture of gasoline from natural gas increased from 414 at the beginning of 1916 to 596 at its close, a gain of about 44 per cent, whereas the combined daily capacity of all plants increased from 232,336 gallons to 495,448 gallons, or about 113 per cent. The accompanying diagrams (fig. 16) show graphically the growth of the natural-gas gasoline industry in the United States since 1911.

STATISTICS OF NATURAL-GAS GASOLINE MARKETED.

The accompanying tables show, by States, the essential statistics of the natural-gas gasoline industry in the United States since 1911.

Gasoline from natural gas marketed in the United States, 1911–1915.

State.	Number of operators.	Plants.		Gasoline produced.			Gas used.		
		Number.	Daily capacity.	Quantity.	Value.	Price per gallon.	Estimated quantity.	Value.	Average yield in gasoline per M cubic feet.
1911.			*Gallons.*	*Gallons.*		*Cents.*	*Cubic feet.*		*Gallons.*
West Virginia	47	72	16,819	3,660,165	$262,661	7.18	1,252,900,600	$76,074	2.92
Ohio	26	39	6,454	1,678,985	118,161	7.04	469,672,000	37,574	3.57
Pennsylvania	43	50	5,669	1,467,043	109,649	7.47	526,152,663	52,615	2.79
Oklahoma	8	8	4,800	388,058	20,975	5.40	144,629,000	4,378	2.68
California, Colorado, Illinois, New York, Kentucky	8	7	3,358	[a] 231,588	20,258	8.75	82,343,000	6,320	2.81
	132	176	37,100	7,425,839	531,704	7.16	2,475,697,263	176,961	3.00
1912.									
West Virginia	66	97	22,366	5,318,136	513,116	9.6	1,972,882,212	163,749	2.8
Pennsylvania	69	83	10,524	2,041,109	217,016	10.6	722,730,117	62,010	2.8
Ohio	25	43	7,791	1,718,719	173,421	10.1	576,123,700	46,090	2.98
Oklahoma	11	13	11,910	1,575,644	99,626	6.3	701,044,300	24,901	2.25
California	7	7	6,669	1,040,695	112,502	10.8	600,743,000	25,573	1.7
Illinois	4	4							
Colorado	2	2	2,008	[a] 386,876	41,795	10.8	114,273,000	9,662	3.4
New York	1	1							
Kentucky	1	.....							
	186	250	61,268	12,081,179	1,157,476	9.6	4,687,796,329	331,985	2.6
1913.									
West Virginia	63	115	31,930	7,662,493	807,406	10.54	2,981,119,000	181,337	2.57
Oklahoma	19	40	61,633	6,462,968	577,944	8.94	2,152,503,000	82,742	3.00
Pennsylvania	100	113	22,207	3,680,096	405,186	11.01	1,372,056,000	114,783	2.68
California	12	14	21,135	3,460,747	376,227	10.87	2,436,445,000	106,539	1.42
Ohio	25	41	8,142	2,072,687	212,404	10.25	744,226,000	63,233	2.79
Illinois	6	12							
Colorado	2	2							
New York	3	3	7,368	[a] 721,826	79,276	10.98	203,092,500	17,590	3.55
Kansas	1	1							
Kentucky	1	.....							
	232	341	152,415	24,060,817	2,458,443	10.22	9,889,441,500	566,224	2.43

[a] Includes gasoline produced in Kentucky which came from natural condensation in gas mains.

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Gasoline from natural gas marketed in the United States, 1911–1915—Continued.

State.	Number of operators.	Plants.		Gasoline produced.			Gas used.		
		Number.	Daily capacity	Quantity.	Value.	Price per gallon.	Estimated quantity.	Value.	Average yield in gasoline per M cubic feet.
1914.			*Gallons.*	*Gallons.*		*Cents.*	*Cubic feet.*		*Gallons.*
Oklahoma	35	58	74,793	17,277,555	1,113,059	6.44	5,738,549,000	273,940	3.01
West Virginia	65	121	34,460	9,278,108	691,899	7.45	3,005,292,000	172,396	2.58
California	17	19	32,360	7,581,309	633,517	8.36	5,129,709,000	197,066	1.48
Pennsylvania	96	119	21,456	4,611,738	359,402	7.79	1,560,064,000	125,690	2.89
Ohio	25	47	9,319	2,440,171	184,097	7.54	852,277,000	68,935	2.86
Illinois	7	14	5,300	1,164,178	100,331	8.62	462,321,000	43,017	2.52
Kansas	3	3							
New York	3	3	1,665	[a] 299,573	23,604	7.88	146,345,000	8,862	2.03
Colorado	2	2							
Kentucky	1	.....							
	254	386	179,353	42,652,632	3,105,909	7.28	16,894,557,000	889,906	2.43
1915.									
Oklahoma	36	63	111,463	31,665,991	2,361,029	7.46	8,791,881,000	435,512	3.60
California	18	20	40,755	12,835,126	975,397	7.60	8,006,888,000	288,669	1.60
West Virginia [b]	66	114	34,422	10,853,608	927,079	8.54	3,526,575,000	150,918	2.30
Pennsylvania [b]	116	139	22,754	5,898,597	569,873	9.66	1,838,034,000	186,325	2.73
Ohio	29	50	8,995	2,198,715	167,138	7.60	785,041,000	77,767	2.80
Illinois	8	16	8,500	1,035,204	80,049	7.73	451,663,000	34,405	2.29
Texas	1	1							
New York	4	4							
Louisiana	2	2	5,447	877,424	70,258	8.01	664,309,000	28,959	1.32
Kansas	3	2							
Colorado	2	2							
Kentucky [b]	2	1							
	287	414	232,336	65,364,665	5,150,823	7.88	24,064,391,000	1,202,555	2.57

[a] Includes gasoline produced in Kentucky which came from natural condensation in gas mains.
[b] Includes gasoline resulting from natural condensation in gas mains.

Gasoline from natural gas marketed in the United States in 1916.

State.	Number of operators.	Plants.		Gasoline produced.			Estimated quantity of gas treated.	Average yield of gasoline per thousand cubic feet of gas.
		Number.	Daily capacity.	Quantity.	Value.	Price per gallon.		
			Gallons.	*Gallons.*		*Cents.*	*M cubic ft.*	*Gallons.*
Oklahoma	77	116	233,077	48,359,602	$5,865,145	12.13	24,749,454	1.954
West Virginia	105	147	98,659	18,765,056	3,025,293	16.12	104,664,536	.179
California	28	26	54,060	17,158,754	2,293,822	13.37	24,826,354	.691
Pennsylvania	167	195	46,487	9,714,926	1,726,173	17.77	38,490,621	.252
Ohio	40	55	18,391	2,638,571	470,804	17.84	5,435,759	.485
Illinois	17	32	12,070	2,260,288	262,664	11.58	1,338,594	1.688
Louisiana	7	7	10,661	2,113,159	269,564	12.76	907,153	2.329
Texas	3	4	6,688	1,292,811	201,023	15.55	948,485	1.363
Kentucky	5	5	11,300	725,467	141,347	19.48	5,614,613	.129
Kansas	4	3	3,030	215,000	35,030	16.29	1,626,635	.132
New York	7	6	1,025	249,055	40,283	16.17	102,819	2.422
Colorado								
	460	596	495,448	103,492,689	14,331,148	13.85	208,705,023	.496

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Classification of production in 1916 by principal methods of manufacture.

Gasoline produced by compression and by vacuum methods.

State.	Plants. Number.	Plants. Daily capacity.	Gasoline produced. Quantity.	Gasoline produced. Value.	Gasoline produced. Price per gallon.	Gas used. Estimated quantity.	Gas used. Average yield in gasoline per M cubic feet.
		Gallons.	*Gallons.*		*Cents.*	*Cubic feet.*	*Gallons.*
Oklahoma	104	215,377	45,827,325	$5,471,307	11.94	14,018,757	3.269
West Virginia	133	39,276	9,289,624	1,642,031	17.67	3,550,523	2.616
Pennsylvania	185	30,287	6,722,370	1,216,717	18.10	2,693,215	2.496
Louisiana	7	10,661	213,159	269,564	12.76	907,153	2.329
Texas	4	6,688	1,292,811	201,023	15.55	948,485	1.363
New York	5	1,025	249,055	40,283	16.17	102,819	2.422
Colorado	1						
California	24						
Ohio	53						
Illinois	29	72,251	19,428,443	2,652,776	13.65	14,492,463	.....
Kentucky	3						
Kansas	2						
	550	375,565	84,922,787	11,493,701	13.53	36,713,415	.....

Gasoline produced by absorption methods.[a]

West Virginia	14	59,383	9,475,432	1,383,262	14.60	101,114,013	0.094
Pennsylvania	10	16,200	2,992,556	509,456	17.02	35,797,406	.084
Oklahoma	12	17,700	2,532,277	393,838	15.55	10,730,697	.236
California	2						
Kentucky	2						
Illinois	3	26,600	3,569,637	550,891	15.43	24,349,492	.....
Ohio	2						
Kansas	1						
	46	119,883	18,569,902	2,837,447	15.28	171,991,608	.....
Grand total	596	495,448	103,492,689	14,331,148	13.85	208,705,023	.496

[a] Includes drips.

NATURAL-GAS GASOLINE INDUSTRY BY STATES.

The accompanying diagrams (figs. 17 and 18) show the relative distribution by States of the marketed production of natural-gas gasoline in 1916 and the relative volume of natural gas treated at gasoline plants in each State in that year.

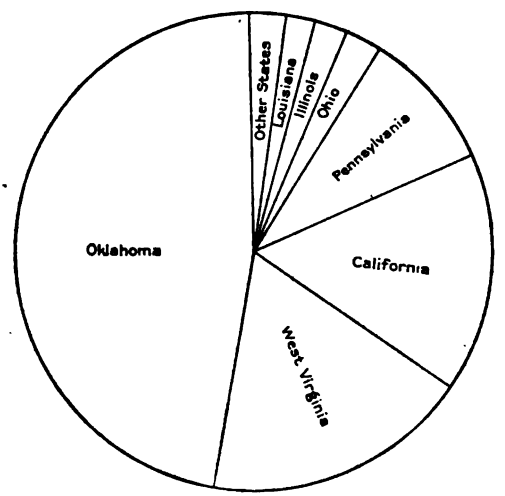

FIGURE 17.—Distribution by States of marketed production of natural-gas gasoline in 1916.

OKLAHOMA.

The quantity of raw gasoline derived from natural gas and marketed in Oklahoma in 1916 was 48,359,602 gallons, an increase of 16,693,611 gallons, or 53 per cent, over the output in 1915. This output was more than two and one-half times the output of natural-gas gasoline in any other State in 1916, and the increase alone was greater than the combined output of this

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material in Pennsylvania, Ohio, and Illinois in that year. Compared with the output of West Virginia, which ranked second in 1916, that of Oklahoma was greater by 29,594,546 gallons, or 158 per cent.

Of the total quantity of natural-gas gasoline marketed from Oklahoma sources in 1916 about 45,827,325 gallons, or 95 per cent, was contributed by 104 plants utilizing compression methods, the remaining 5 per cent representing the output of 12 absorption plants, plus the gasoline recovered as drips from gas mains in Oklahoma.

The total number of gasoline plants in operation in Oklahoma at the end of 1916 was 116, a net gain of 53 plants, or 84 per cent, over the number in operation at the end of 1915. The combined daily capacity of all gasoline plants in Oklahoma at the end of 1916 was 233,077 gallons, a gain of 121,614 gallons, or 109 per cent, over the productive capacity of the plants in this State at the end of 1915.

The average price received at the plants for the unblended or raw gasoline marketed in Oklahoma in 1916 was 12.13 cents a gallon, and the market value of the entire quantity sold was $5,865,145, a gain of 4.67 cents in the average unit selling price and of $3,504,116, or 148 per cent, in the market value of the output, compared with 1915.

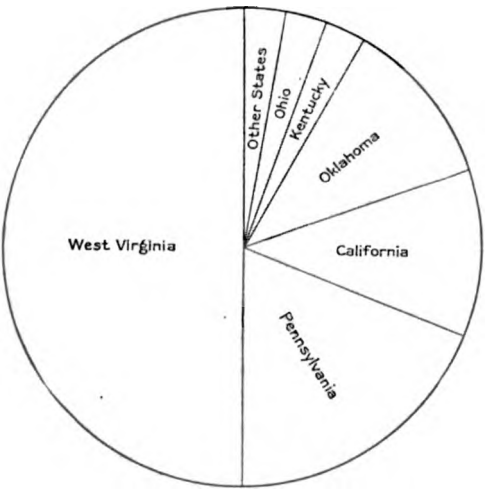

FIGURE 18.—Distribution by States of natural gas treated in the manufacture of natural-gas gasoline in the United States in 1916.

The volume of natural gas treated in the production of natural-gas gasoline in Oklahoma in 1916 is estimated at 24,749,454,000 cubic feet, or about 20 per cent of the total volume produced commercially in the State in that year. Of this volume 14,018,757,000 cubic feet, or 57 per cent, yielded an average of 3.3 gallons of raw gasoline per thousand cubic feet by compression methods, the remaining 43 per cent yielding an average of 0.2 gallon per thousand cubic feet by absorption methods.

The following tables show the production of gasoline from natural gas in Oklahoma in 1915 and 1916 and include details by counties of the gasoline produced by compression methods.

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Gasoline from natural gas marketed in Oklahoma in 1915 and 1916.

1915.

County.	Plants.		Gasoline produced.		Average yield in gasoline per thousand cubic feet of gas.	Average gravity of gasoline as produced and before blending.
	Number in operation.	Daily capacity.	Quantity.	Value.		
		Gallons.	*Gallons.*		*Gallons.*	*° Baumé.*
Creek	32	70,949	20,589,631	$1,496,177	0.5–8.0	70–96
Nowata	6	16,950	4,852,933	427,120	2.0–4.0	72–82
Tulsa	9	13,363	4,039,249	271,626	2.0–5.1	80–94
Okmulgee	6	4,275	855,992	68,707	1.0–2.5	76–87
Muskogee	6	4,036	704,188	56,199	2.5–4.5	85–94
Pawnee	1	1,890	623,998	41,200	0.6–2.0	70–92
Washington	3					
	63	111,463	31,665,991	2,361,029	3.60	70–96

1916.

County.	Number of operators.	Plants.		Gasoline produced.		Estimated quantity of gas treated.	Average yield of gasoline per thousand cubic feet of gas.	Average gravity of gasoline as produced and before blending.
		Number.	Daily capacity.	Quantity.	Value.			
			Gallons.	*Gallons.*		*M. cu. ft.*	*Gallons.*	*° Baumé.*
Creek	24	36	105,742	24,159,720	$2,500,218	6,032,636	1.4–7.8	72–96
Nowata	9	12	37,400	9,333,075	1,191,982	2,116,831	1.4–6.1	78–96
Tulsa	12	19	25,135	6,503,102	886,466	2,303,667	1.2–3.5	72–95
Okmulgee	13	18	20,100	3,062,438	431,409	2,080,671	0.6–5.7	79–95
Washington	4	6	8,900	1,124,873	221,711	645,301	2.0–	82–89
Muskogee	8	9	6,000	1,086,536	158,211	616,791	1.3–3.5	64–90
Rogers	2	3	12,100	537,581	81,310	222,860	2.0–2.5	72–82
Pawnee	2	1					3.0	72
Kay	a 2	.....	.....	.....	.....	.....	.....	.....
Osage	a 1	.....	.....	.....	.....	.....	.....	.....
Total by compression	.....	104	215,377	45,827,325	5,471,307	14,018,757	3.269	64–96
Total by absorption and drip	.....	12	17,700	2,532,277	393,838	10,730,697	0.236	68–80
Total	77	116	233,077	48,359,602	5,865,145	24,749,454	1.954	64–96

a Absorption plants and drip only.

WEST VIRGINIA.

By increasing its output of gasoline obtained from natural gas from 10,853,608 gallons in 1915 to 18,765,056 gallons in 1916, a gain of 73 per cent, West Virginia advanced from third to second rank among the States in which this industry has been developed, exceeding its closest competitor, California, by a margin of approximately 1,600,000 gallons.

Of the total quantity of natural-gas gasoline marketed from sources in West Virginia in 1916, approximately 9,289,624 gallons, or 49 per cent of the entire output, was supplied by 133 plants utilizing either compression and condensation or vacuum pump methods, the

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remainder comprising the output of 14 absorption plants and the drips recovered from gas mains in the State. The volume of natural gas treated in the production of gasoline in West Virginia in 1916 is estimated at 104,664,536,000 cubic feet, or about 35 per cent of the total volume produced in the State in that year. Of this volume it is estimated that 3,550,523,000 cubic feet, or 3 per cent, furnished an average of 2.6 gallons of gasoline to the thousand cubic feet, and that the remaining 97 per cent of the gas treated furnished an average of 0.09 gallon of gasoline to the thousand cubic feet.

The average price received at the plants for gasoline marketed in West Virginia in 1916 was 16.12 cents a gallon and the market value of the entire output was $3,025,293, a gain of 7.58 cents in average sale price per gallon and of $2,098,214, or 226 per cent, in gross market value, compared with 1915.

The total number of gasoline plants in operation in West Virginia at the end of 1916 was 147, and their combined daily capacity was 98,659 gallons, a net gain of 33, or 28 per cent, in the number of plants and of 64,237 gallons, or 187 per cent, in the daily capacity of gasoline plants in the State, compared with conditions at the end of 1915.

The following tables include comparative statistics of the natural-gas gasoline industry in West Virginia in the last two years, and contain details by counties of gasoline produced by compression and condensation methods:

Gasoline from natural gas marketed in West Virginia, 1915 and 1916.

1915.

County.	Plants.		Gasoline produced.		Average yield in gasoline per thousand cubic feet of gas.	Average gravity of gasoline as produced and before blending.
	Number in operation.	Daily capacity.	Quantity.	Value.		
		Gallons.	*Gallons.*		*Gallons.*	° *Baumé.*
Tyler	46	14,047	3,784,573	$319,821	2.0–7.0	74–92
Ritchie	16	5,245	1,331,425	109,296	1.0–4.0	80–90
Kanawha	7	7,007	1,024,845	75,963	0.3–4.5	75–100
Brooke	9	2,325	603,419	55,568	2.0–6.0	84–92
Pleasants	13	1,615	426,961	33,677	2.0–3.0	80–90
Hancock	4	780	297,653	24,475	1.5–6.0	86–92
Wetzel	5	975	185,998	15,271	1.0–2.0	78–86
Doddridge	3	650	116,000	9,520	2.0–2.5	84–89
Wood	6	530	70,201	6,088	1.0–2.5	80–90
Clay	1					
Harrison	1					
Marion	1	1,248	[a] 3,012,533	277,400	0.3–2.0	75–90
Roane	1					
Calhoun	1					
	114	34,422	10,853,608	927,079	2.3	74–100

[a] Includes drips.

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Gasoline from natural gas marketed in West Virginia, 1915 and 1916—Continued.

1916.

County.	Number of operators.	Plants. Number.	Plants. Daily capacity.	Gasoline produced. Quantity.	Gasoline produced. Value.	Estimated quantity of gas treated.	Average yield of gasoline per thousand cubic feet of gas.	Average gravity of gasoline as produced and before blending.
			Gallons.	*Gallons.*		*M. cu. ft.*	*Gallons.*	° *Baumé.*
Tyler	19	53	14,430	4,424,890	$780,928	1,501,201	0.8– 6.0	75–94
Kanawha	8	7	9,287	1,566,461	287,856	469,887	2.5– 5.0	76–82
Ritchie	11	15	3,628	1,011,902	175,566	568,667	0.8– 3.3	80–90
Brooke	11	11	2,639	626,464	111,893	193,029	2.0– 3.5	80–94
Wetzel	9	8	1,832	420,369	76,579	254,065	1.0– 2.0	70–86
Hancock	8	6	1,260	314,458	52,685	79,303	2.0–10.0	78–95
Pleasants	15	19	1,690	299,025	46,852	121,348	2.0– 3.0	79–90
Roane	3	3	970	261,940	44,850	124,891	1.3– 3.0	80–88
Wood	6	4	680	59,472	8,510	26,274	1.2– 3.0	80–86
Harrison		2					0.5– 1.5	84–85
Doddridge		2					1.0– 2.5	81–88
Clay	a 15	1	2,810	304,643	56,312	211,856	2.0	82
Wirt		1					3.0	89
Calhoun		1					0.5	92
Total by compression and vacuum		133	39,276	9,289,624	1,642,031	3,550,523	2.616	70–95
Total by absorption and drip		14	59,383	9,475,432	1,383,262	101,114,013	0.094	68–86
	105	147	98,659	18,765,056	3,025,293	104,664,536	0.179	68–95

a Includes operators having absorption plants in Monongalia, Cabell, Jackson, Lewis, and Marion counties.

CALIFORNIA.

Although the quantity of gasoline produced from natural gas and marketed in California in 1916 exceeded the quantity marketed in any previous year, this State was relegated to third rank by reason of the more rapid growth of the industry in West Virginia.

The quantity of gasoline obtained from natural gas in California in 1916 was 17,158,754 gallons, a gain of 4,323,628 gallons, or 34 per cent, over the output in 1915.

The volume of gas treated in the production of this gasoline is estimated at 24,826,354,000 cubic feet, or about 78 per cent of the total volume produced and marketed in California in 1916. As a consequence of the installation of absorption plants in Orange and Fresno counties for the treatment of lean gas, the average yield per thousand cubic feet of gas treated at gasoline plants in California decreased from 1.60 gallons in 1915 to 0.69 gallon in 1916, whereas the total volume of gas treated increased threefold.

The average price received at the plants for gasoline marketed in California in 1916 was 13.37 cents a gallon, and the market value of the entire output was $2,293,822, a gain of 5.77 cents in average unit selling price and of $1,318,425, or 135 per cent, in gross market value, compared with 1915.

At the end of 1916 there were 26 plants having a combined daily capacity of 54,060 gallons of gasoline in active operation in California, a net gain of 6 plants and of 13,305 gallons in daily capacity during the year.

The following tables include comparative statistics of the natural-gas gasoline industry in California in 1915 and 1916:

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Gasoline from natural gas marketed in California in 1915 and 1916.

1915.

County.	Plants.		Gasoline produced.		Average yield in gasoline per thousand cubic feet of gas.	Average gravity of gasoline as produced and before blending.
	Number in operation.	Daily capacity.	Quantity.	Value.		
		Gallons.	*Gallons.*		*Gallons.*	° *Baumé.*
Santa Barbara	7	18,967	6,932,284	$505,576	1.05–2.35	68–82
Orange	5	11,736	2,977,144	233,837	1.0 –2.5	67–75
Los Angeles	5	4,634	959,043	83,158	0.57–2.0	66–80
Kern	1					
Ventura	1	5,398	1,966,655	152,826	0.5 –2.0	69–80
Fresno	1					
	20	40,755	12,835,126	975,397	1.603	66–82

1916.

County.	Number of operators.	Plants.		Gasoline produced.		Estimated quantity of gas treated.	Average yield in gasoline per thousand cubic feet of gas.	Average gravity of gasoline as produced and before blending.
		Number.	Daily capacity.	Quantity.	Value.			
			Gallons.	*Gallons.*		*M. cu. ft.*	*Gallons.*	° *Baumé.*
Santa Barbara	6	7	21,642	7,462,566	$1,046,308	4,806,583	1.0 –2.5	72–81
Kern	8	5	10,488	[a] 3,353,438	483,729	11,916,940	0.025–1.0	60–75
Orange	7	7	12,700	[b] 3,026,652	368,785	2,592,613	0.5 –3.0	67–81
Los Angeles	5	4	4,330	1,155,758	146,850	1,951,101	0.3–2.0	65–80
Ventura	1	1	4,900	[c] 2,160,340	248,150	3,559,117	1.84	85.3
Fresno	1	2					0.3 –1.2	62–75
	28	26	54,060	17,158,754	2,293,822	24,826,354	0.691	60–85.3

[a] Includes drips.
[b] Includes gasoline made by the absorption process at one plant.
[c] Includes Los Angeles County drips and gasoline made by absorption process at one plant in Fresno County.

PENNSYLVANIA.

As contributor of 9 per cent of the gasoline produced from natural gas and marketed in the United States in 1916, Pennsylvania, the birthplace of the natural-gas gasoline industry, ranks only fourth among the States in which this industry has been developed.

The quantity of gasoline produced from natural gas in Pennsylvania in 1916, which amounted to 9,714,926 gallons, was greater than the output in any preceding year, and exceeded the output in 1915 by 3,816,329 gallons, or 65 per cent. Its value at the plants, which amounted to $1,726,173, shows an even greater rate of increase compared with the value of the output in 1915, the gain being $1,156,300, or 203 per cent, and resulting from an increase of 8.11 cents a gallon, or 84 per cent, in the average selling price. The advance in 1916 was from 9.66 cents to 17.77 cents and is accounted for in part by the country-wide appreciation of gasoline values in 1916 and in part by the fact that many producers of natural-gas gasoline in Pennsylvania blend their product at the plants and market it direct to consumers.

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Of the total quantity of natural-gas gasoline produced in Pennsylvania in 1916, it is estimated that 6,722,370 gallons, or 69 per cent, was produced by the treatment of 2,693,215,000 cubic feet of natural gas at 185 plants employing either compression or vacuum pump methods. The volume of gas treated by these methods was 7 per cent of the total volume treated in 1916, and its average yield of gasoline per thousand cubic feet was 2.5 gallons. The remaining 31 per cent of the gasoline marketed represents the results of the treatment of some 35,797,406,000 cubic feet of gas at 10 absorption plants plus the quantity of gasoline recovered as drips from gas mains in the State during 1916. The average recovery of gasoline from natural gas treated by absorption methods in Pennsylvania in 1916 was 0.08 gallon to the thousand cubic feet. The total volume of gas treated at gasoline plants in Pennsylvania in 1916 constitutes about 30 per cent of the volume marketed from sources within the State in that year.

The total number of gasoline plants in operation in Pennsylvania at the end of 1916 was 195, a net gain of 56 plants, or 40 per cent, over the number at the end of 1915. The combined daily capacity of all plants at the end of 1916 was 46,487 gallons of gasoline a day, a net increase of 23,733 gallons, or 104 per cent, in daily productive capacity during the year.

The following tables include comparative statistics of the natural-gas gasoline industry in Pennsylvania in the last two years and contain details by counties of gasoline produced by compression methods:

Gasoline from natural gas marketed in Pennsylvania in 1915 and 1916.

1915.

County.	Plants.		Gasoline produced.		Average yield in gasoline per thousand cubic feet of gas.	Average gravity of gasoline as produced and before blending.
	Number in operation.	Daily capacity.	Quantity.	Value.		
		Gallons.	*Gallons.*		*Gallons.*	*° Baumé.*
Warren	35	4,057	1,291,313	$115,635	1.0–8.0	66–100
McKean	13	8,450	1,204,080	135,974	1.5–4.3	68– 97
Butler	60	4,301	1,032,661	96,637	0.5–7.0	72– 95
Forest	4	2,100	543,778	55,275	2.0–4.0	85– 95
Allegheny	12	1,800	518,871	42,188	1.0–5.0	81– 88
Washington	4	500			3.0–5.0	80– 82
Venango	3	935			2.0–4.0	85– 95
Crawford					1.0–5.0	.....
Potter			[a] 1,307,894	125,164	1.5	.....
Greene	8	611			2.5	.....
Armstrong					0.5–4.0	70– 82
Clarion					1.0–3.0	71– 80
	139	22,754	5,898,597	569,873	2.73	66–10

[a] Includes drips.

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Gasoline from natural gas marketed in Pennsylvania in 1915 and 1916—Continued.

1916.

County.	Number of operators.	Plants. Number.	Plants. Daily capacity.	Gasoline produced. Quantity.	Gasoline produced. Value.	Estimated quantity of gas treated.	Average yield of gasoline per thousand cubic feet of gas.	Average gravity of gasoline as produced and before blending.
			Gallons.	*Gallons.*		*M. cu. ft.*	*Gallons.*	° *Baumé.*
McKean	11	12	9,085	1,780,159	315,799	733,417	1.5–3.0	71–92
Warren	32	40	5,245	1,513,725	286,860	437,259	1.0–8.0	66–98
Butler	79	87	5,175	1,277,516	219,387	485,598	0.5–6.0	64–90
Forest	10	11	4,066	878,625	163,750	324,344	2.0–5.0	85–94
Allegheny	7	15	2,700	693,109	124,859	175,950	1.5–5.0	78–87
Venango	6	5	2,250	324,750	60,552	386,330	0.5–5.0	85–90
Washington	4	4	255	87,671	16,250	39,355	1.0–5.0	80–86
Beaver	3	3	120	26,700	4,986	9,200	2.5–5.0	80–86
Potter	[a] 15	1	1,391	140,115	24,274	101,762	1.0	90
Clarion		2					1.0–2.0	77–80
Crawford		1					1.0–5.0	85
Armstrong		2					0.5–4.5	76–85
Greene		2					2.5	.....
Total by compression and vacuum	.....	185	30,287	6,722,370	1,216,717	2,693,215	2.496	64–98
Total by absorption and drip	.....	10	16,200	2,992,556	509,456	35,797,406	0.084	70–83
	167	195	46,487	9,714,926	1,726,173	38,490,621	0.252	64–98

[a] Includes one company operating an absorption plant in Elk County.

OHIO.

Though contributing but 2.5 per cent of the gasoline derived from natural gas and marketed in the United States in 1916, Ohio retained fifth place among the States in which this industry has been developed, a position it has maintained since 1913, despite the close competition of Illinois for this honor.

The quantity of natural-gas gasoline produced in Ohio in 1916 was 2,638,571 gallons, a gain of 439,856 gallons, or 20 per cent, over the output in 1915, and of 198,400 gallons, or 8 per cent, over the output in 1914, which constituted the record yield in this State prior to 1916.

The average price received at the plants for the gasoline marketed in Ohio in 1916 was 17.84 cents a gallon and the market value of the entire output was $470,804, a gain of 10.24 cents in the average unit selling price and of $303,666, or 182 per cent, in gross market value, compared with 1915.

At the end of 1916 there were in Ohio 55 plants—two of which employed absorption methods—for the manufacture of gasoline from natural gas, a net gain of 5 plants, or 10 per cent, during the year. The combined daily capacity of the plants in operation at the end of 1916 was 18,391 gallons, an increase of 9,396 gallons, or 104 per cent, in daily capacity during 1916.

The effect of the operation of two absorption plants in Ohio during the greater part of 1916 was greatly to increase the total volume of gas treated in that year compared with preceding years and to lower the average yield of gasoline per thousand cubic feet of gas treated, owing to the fact that the gas treated by absorption methods was of the type commonly designated as "dry" or "pipe-line" gas, that con-

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tained only about one-tenth gallon of gasoline to the thousand cubic feet.

The volume of gas treated at gasoline plants in Ohio in 1916 is estimated at 5,435,759,000 cubic feet, about 7 per cent of the total volume produced and marketed in the State in 1916. From this volume an average of 0.485 gallon of gasoline was obtained per thousand cubic feet. Compared with corresponding statistics for 1915, these data show gain of 4,650,718,000 cubic feet, or 592 per cent, in the volume of gas treated, but decrease of 2.31 gallons in the average recovery of gasoline per unit volume of gas treated.

The following tables show, by counties, details of the natural-gas gasoline industry in Ohio in the last two years:

Gasoline from natural gas marketed in Ohio, 1915 and 1916.

1915.

County.	Plants.		Gasoline produced.		Average yield in gasoline per thousand cubic feet of gas.	Average gravity of gasoline as produced and before blending.
	Number in operation.	Daily capacity.	Quantity.	Value.		
		Gallons.	*Gallons.*		*Gallons.*	*° Baumé.*
Monroe	31	5,920	1,562,387	$113,410	0.5–6.6	74–96
Jefferson	5	820	249,940	18,978	1.0–3.0	85–96
Washington	9	900	222,543	21,207	2.0–3.0	80–96
Columbiana	2					
Morgan	2	1,355	163,845	13,543	2.0–3.5	85–91
Fairfield	1					
	50	8,995	2,198,715	167,138	2.8	74–96

1916.

County.	Number of operators.	Plants.		Gasoline produced.		Estimated quantity of gas treated.	Average yield of gasoline per thousand cubic feet of gas.	Average gravity of gasoline as produced and before blending.
		Number.	Daily capacity.	Quantity.	Value.			
			Gallons.	*Gallons.*		*M. cu. ft.*	*Gallons.*	*° Baumé*
Monroe	14	28	4,562	1,446,917	$263,336	557,685	1.0–8.0	76–92
Jefferson	11	10	1,226	371,925	64,985	194,027	0.5–3.7	82–100
Washington	8	10	858	239,866	41,789	70,575	1.0–5.0	82–91
Ashland	1	[a] 1					.1046	78–86
Columbiana	2	2					3.5000	85–90
Fairfield	1	1	11,745	[b] 579,863	110,694	4,613,472	3.0000	85
Licking	1	[a] 1					.1084	77
Morgan	2	2					2.5000	89
	40	55	18,391	2,638,571	470,804	5,435,759	0.4850	76–100

[a] Absorption plants. [b] Includes gasoline made by absorption process.

ILLINOIS.

The quantity of gasoline produced from natural gas in Illinois in 1916 constituted only 2.2 per cent of the output of this commodity in the entire United States in that year. The quantity involved, which was 2,260,288 gallons, constituted a gain of 1,225,084 gallons, or 118 per cent, over the marketed output from this State in 1915.

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The market value of the output in 1916 was $262,664, and the average selling price per gallon at the sources of production was 11.58 cents, a gain of $182,615, or 228 per cent, in the market value and of 3.85 cents in average unit selling price, compared with 1915.

The number of plants for the manufacture of gasoline from natural gas in Illinois increased in 1916 from 16 to 32, a gain of 100 per cent, inclusive of three absorption plants installed by one company in Lawrence County during the year. As in other States the statistical effect of the operation of these absorption plants was to increase the volume of gas treated and to lower the average recovery of gasoline per unit volume of the gas.

The volume of gas treated at gasoline plants in Illinois in 1916 is estimated at 1,338,594,000 cubic feet, or about 38 per cent of the volume produced and marketed in that State during the year. This volume, however, was greater by about 886,931,000 cubic feet, or 196 per cent, than that treated for gasoline in Illinois in 1915.

From the gas treated in 1916, an average of 1.69 gallons of gasoline was obtained, a net decrease of 0.60 gallon per thousand cubic feet from the average in 1915. As already suggested, this decrease does not indicate any diminution in the relative richness of Illinois gas in content of gasoline vapors or any loss in efficiency of gasoline plant operation in that State, but merely a gratifying increase in the use of lean gas for manufacture of gasoline.

The following table includes statistical details by counties of the natural-gas gasoline industry in Illinois in 1916:

Gasoline from natural gas marketed in Illinois in 1915 and 1916.

County.	Number of operators.	Plants.		Gasoline produced.		Estimated quantity of gas treated.	Average yield of gasoline per thousand cubic feet of gas.	Average gravity of gasoline as produced and before blending.
		Number.	Daily capacity.	Quantity.	Value.			
			Gallons.	*Gallons.*		*M. cu. ft.*	*Gallons.*	*° Baumé.*
Lawrence[a]	8	22	9,300	1,928,974	$223,773	1,196,615	1.0–2.5	70–87
Crawford	8	10	2,770	331,314	38,891	141,979	1.5–4.0	60–88
Clark	1							
Total, 1916	17	32	12,070	2,260,288	262,664	1,338,594	1.688	60–88
Total, 1915	8	16	8,500	1,035,204	80,049	451,663	2.29	72–94

[a] Includes statistics of one operator using absorption method.

LOUISIANA.

The year 1916 was one of decided expansion in the natural-gas gasoline industry in Louisiana, as a consequence of which this State advanced in rank from ninth to seventh place among the States in which this industry has been developed.

Seven gasoline plants, 5 of which commenced operations in 1916, furnished 2,113,159 gallons of gasoline in 1916, this quantity constituting about 2 per cent of the output of the entire country in that year.

The market value of this output was $269,564 and the average selling price was 12.76 cents a gallon.

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The volume of gas treated in the production of this quantity of gasoline is estimated at 907,153,000 cubic feet, about 3 per cent of the volume produced and marketed in Louisiana in 1916, the average yield per thousand cubic feet of gas being about 2.33 gallons of gasoline.

The relatively high yield of gasoline per unit volume of gas treated in Louisiana compared with other States is accounted for by the fact that the gasoline plants in this State all employ compression and condensation methods, which are feasible of operation only on gas that carries a minimum of 1 gallon of gasoline to the thousand cubic feet.

At the end of 1916 gasoline plants were in operation in Louisiana as follows: In Caddo Parish, 1 plant each by the Central Oil & Gasoline Co. and the Producers Oil Co., and 2 plants by the Standard Oil Co. of Louisiana; in De Soto Parish, 1 plant each by the Producers Oil Co., the Standard Oil Co. of Louisiana, and the De Soto Gasoline Co. At the end of 1916 new plants were being installed in Caddo Parish by the Gulf Refining Co. of Louisiana and by the Bayou Gasoline Co., and in De Soto Parish by the Gulf Refining Co. of Louisiana.

The following table includes statistical details by parishes of the natural-gas gasoline industry in Louisiana in 1916:

Gasoline from natural gas marketed in Louisiana in 1916.

County.	Number of operators.	Plants.		Gasoline produced.		Estimated quantity of gas treated.	Average yield of gasoline per thousand cubic feet of gas.	Average gravity of gasoline as produced and before blending.
		Number.	Daily capacity.	Quantity.	Value.			
			Gallons.	*Gallons.*		*M. cu. ft.*	*Gallons.*	*°Baumé.*
Caddo	4	4	8,006	1,803,151	$227,067	813,750	1.5–3.3	64–80
De Soto	3	3	2,655	310,008	42,497	93,403	3.0–4.0	76–78
	7	7	10,661	2,113,159	269,564	907,153	2.329	64–80

TEXAS.

Substantial progress was made in 1916 in the development of the natural-gas gasoline industry in Texas, the output of gasoline credited to this State constituting 1.2 per cent of the output of the entire country in that year. Four plants, 3 of which commenced operations during the year, furnished this output, which amounted to 1,292,811 gallons.

The market value of this output was $201,023 and the average price per gallon received at the plants was 15.55 cents. It is estimated that 948,485,000 cubic feet of gas, about 6 per cent of the volume marketed in the State in 1916, was treated in the production of gasoline and that the average recovery per thousand cubic feet of gas was 1.36 gallons.

The production of gasoline from natural gas in Texas in 1916 was all by compression and condensation methods. The facilities for manufacture of gasoline comprised 4 plants, having a combined daily

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capacity of 6,688 gallons, located in Wichita County and owned, respectively, by the Magnolia Petroleum Co. (2 plants), the Producers Oil Co., and the Red River Oil Co. At the end of 1916 one plant was being installed by the Magnolia Petroleum Co. in the Thrall district, Williamson County.

KENTUCKY.

The output of 725,467 gallons of gasoline credited to Kentucky in 1916 represents the output of 5 plants, 2 of which were absorption plants installed during the year, and includes a considerable quantity of gasoline recovered as drips from natural-gas transmission lines. This output is considerably greater than that in any preceding year.

The market value of the gasoline obtained from natural gas in Kentucky in 1916 was $141,347 and the average selling price per gallon was 19.48 cents, this price being higher than the average received for natural-gas gasoline at plants in any other State.

The volume of natural gas treated in the production of this quantity of gasoline was about 5,614,613,000 cubic feet, much of which came from wells in West Virginia, and the average recovery of gasoline per thousand feet was about 0.13 gallon. At the end of 1916 plants for the manufacture of gasoline from natural gas were in operation in Kentucky as follows: Wayne County, 2, operated respectively by the Wood Oil Co. and the New Domain Oil & Gas Co.; Morgan County, 1, operated by the Morgan County Heat & Light Co.; Boyd and Martin counties, 1 plant each, operated by the United Fuel Gas Co.

KANSAS.

The natural-gas gasoline industry in Kansas was restricted in 1916 to Chautauqua County, where 3 plants were operated. Two of these, operated respectively by the Hi Grade Petroleum & Gasoline Co. (formerly operated by the Sedan Gasoline Co.) and the Vulcan Oil & Gas Co., were compression and condensation plants, and the other, operated by the Wichita Natural Gas Co., was an absorption plant put in operation during the year. The combined output of these plants in 1916 was 215,000 gallons, and its market value was $35,030, at an average price of 16.29 cents a gallon. The volume of gas treated in the production of this gasoline is estimated at 1,626,635,000 cubic feet and the average recovery of gasoline per thousand cubic feet at 0.13 gallon.

New plants for the treatment of natural gas by absorption methods were under construction in Kansas at the end of 1916 in Butler and Cowley counties.

NEW YORK.

Five plants, all operating by compression and condensation methods, furnished the output of natural-gas gasoline in New York in 1916. Two of these plants, operated respectively by the Royal Gasoline Co. and the Wirt Gasoline Co., are located in Allegany County, and the three remaining plants operated respectively by the Pennsylvania Gasoline Co., the Power Gasoline Co., and the Warren Gasoline Co. (which purchased the plant in 1916 from Curtis & Moore), are located in Cattaraugus County. The combined capacity of these

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plants is about 1,000 gallons of gasoline a day and the gasoline content of the gas used averages about 2 gallons to the thousand cubic feet.

COLORADO.

One plant in the Boulder field, owned by the Boulder-Greeley Oil Co., furnished the small quantity of gasoline obtained from natural gas and sold in Colorado in 1916. About 4 gallons of raw gasoline are obtained at this plant from every thousand cubic feet of gas treated.

CARBON BLACK FROM NATURAL GAS.

In order to satisfy to some extent at least the many requests received by the United States Geological Survey for information concerning the methods employed in the manufacture of carbon black from natural gas, the following abstract of a paper [1] on this subject, by one of the principal manufacturers of carbon black in the United States, is reprinted from the 1913 report of this series:

In the American trade the term "lampblack" is usually understood to be a soot deposited by the smudge process and made from oil, resin, or some other solid or liquid raw material, whereas "carbon black" is the term applied to a black deposited by actual contact of a flame upon a metallic surface.

If the name "lampblack" be taken in its wider sense as meaning any commercial form of soot, it may be prepared in three different ways: First, by the combustion of dead oil of tar, pitch, resin, or some other carbonaceous raw material with an inadequate supply of air and the collection of the floating particles of soot that escape unburned from the flame and slowly deposit themselves on the walls and floors of the collecting chambers; second, it may be formed by the direct impact of a flame upon a collecting surface; and, third, it may be formed by heating carbonaceous vapors to a decomposing point, apart from air or flame.

If lampblack be restricted to the sense in which it is known to the American trade of a commercial soot deposited by the smudge process, the starting point of its manufacture is usually the dead oil of tar, an oil containing a large proportion of naphthalene, a certain proportion of phenol, and various aromatic hydrocarbons particularly suited to the manufacture of lampblack by reason of the large percentage of carbon therein contained. When this dead oil of tar is burnt with an inadequate supply of air, a very considerable proportion—to wit, from 15 to 35 per cent of its weight—can be obtained in the form of lampblack by decomposition in suitably arranged chambers. The quality of the black is determined by the size and shape of the furnaces in which the oil is burned, by the heat to which it is subjected in the process of manufacture, by the position in which the black is deposited, and by the care that is exercised in the process of manufacture and in the selection and preparation of the raw materials.

The oil is usually allowed to flow in a sluggish stream into an earthenware or iron pot or pan, in which it burns and from which the smoke passes through flues into the chambers in which it is deposited.

To absorb and utilize commercially some of the heat, boilers are often placed within reach of the flame and the steam thus generated is used for the industrial processes that may take place in the same factory. Care is necessary to free entirely from water whatever raw material may be employed and also to protect the reservoirs and the pipes from them to the burners from excessive cold, which might cause a stoppage by the coagulation of naphthalene, anthracene, or other solid matter in the pipes. A screen is often used at the final exit from the black-condensing chambers in order to hold back the last traces of the black, both on account of its value and because the smoke that passes from a lampblack factory is very annoying to neighbors.

The best grades of black, in general, are obtained in furnaces of moderate size, so built that the black is practically calcined at the time it is deposited and carries down with it but very little empyreumatic matter. The products of combustion are usually carried through a series of chambers and the black is assorted according to its distance from the point of origin, the lightest being that farthest from the flame and for this reason commanding better prices for certain purposes.

[1] Cabot, G. L., Paper read before Eighth Int. Cong. Appl. Chemistry, vol. 12, pp. 13 et seq.; abstract printed in U. S. Geol. Survey Mineral Resources, 1913, pt. 2, pp. 1488–1499, 1914.

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These chambers are periodically emptied, preparatory to which it is needful to be sure that the black is thoroughly cold and is not afire, for it sometimes happens, if too much oxygen comes into the chambers, that the black gets afire and the fire may lurk undetected, unless great care be exercised. An experienced workman can usually detect fire by the smell, and the workmen are thus put on their guard to hunt out and extinguish the fire. It sometimes happens that the quantity of carbonic-oxide gas is dangerous to the workmen, and this danger should be borne in mind. This gas is very poisonous.

It has been observed that the smokiness of a flame can be increased by artificial cooling; for example, if a coarse wire grating is brought into an ordinary gas flame, the flame immediately begins to smoke, and various attempts have been made to utilize this principle to increase the yield of lampblack.

It is good practice to introduce partition walls in the chambers used for deposition, thereby increasing the distance that the products of combustion must travel before they finally escape into the open air, with a view to increasing the percentage of deposition; but this practice can easily be overdone, for if the chambers are divided up too much more harm is done by increasing the speed with which the products of combustion travel than good by increasing the distance.

Mechanical devices have been used in the form of stirrers, which churn the air and cause the condensation of the smoke in masses sufficiently large for it to deposit itself. The writer cited does not know whether any of these devices are now in use on a commercial scale. The soot thus obtained contains about 80 per cent of carbon, the rest being chiefly oxygen and hydrogen, with traces of grit on the walls and floors of the collecting chambers and a greater or less percentage of oil or other empyreumatic matter.

This oil or other empyreumatic matter can be driven off by heating the lampblack in sheet-iron boxes, care being taken, on the one hand, to heat it sufficiently to drive off the oil, and, on the other, not to make it so hot as to affect the mixing strength. Moreover, it is possible, as already stated, by a proper proportioning of the fireplace, flues, and the supply of raw material and a proper arrangement of the temperature and other conditions, to cause a deposition of a certain proportion of black practically free from empyreumatic matter from the start.

Resin, resinous woods, tar, pitch, and other raw materials have been and still are, to a certain extent, used in the manufacture of lampblack; but in general the quality of the black thus obtained is less good than that obtained from the dead oil of tar and other distillates, and such inferior raw materials are comparatively unimportant as a commercial source of lampblack.

Another method of making lampblack is by the heating of hydrocarbon vapors out of contact with air, a typical instance of which is set forth in patent No. 866883, by Albert D. Purtle and Irving E. Rowland, of Salem, W. Va. For years a similar process was used to extract carbon from natural gas to be used in the manufacture of electric-light pencils, near Red Bank, Pa.; but the carbon thus obtained cost too much to compete in the long run with coke, which is now the chief raw material for these pencils. Lampblack thus obtained is apt to contain particles of adamantine carbon, so hard that they will scratch glass. Another commercial obstacle is the high cost of the apparatus and the large expense from deterioration as compared with the value of the finished product. Therefore, although a much larger proportion of carbon can be obtained from natural gas by this than by any other known process, all such efforts have, up to this time, failed to show a commercial profit; but it is believed that this method of making carbon black will some time be successfully applied.

Attempts have been made, first, to volatilize the raw material and, second, to burn the resulting vapor on the smudge system with an insufficient supply of air and to collect the resulting soot; but it is not known that any such attempts have proved profitable on a commercial scale, and it is hardly believed that they would.

Various devices have been adopted to perfect the separation of the soot from the air, and it may be said that, both in the manufacture of lampblack by the ordinary smudge process and in the manufacture of carbon black by the contact process, one of the most difficult problems is the proper separation of the black from the air in which it floats or which it holds mechanically when it settles. In the case of the smudge process, adjustable blinds made of iron are sometimes used, by which the black enters the chimney and which can be worked just like the adjustable slats on an ordinary window blind. Thus, the draft is regulated and eddies are formed which help to cause the black to unite into larger pieces and to settle out. High-pressure electric discharges of a static machine have been used experimentally for causing this separation of the black from the air, but this is a too expensive and cumbersome method to prove profitable on a commercial scale, and, of course, on a large scale, high-pressure discharges are dangerous. The best material for the chambers in which

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the black settles is masonry, with cement floors and a brick roof put together with cement mortar.

When a new plant is put into operation, the black first made is apt to contain moisture condensed by the coldness of the walls, empyreumatic matter, which has not been calcined out for the same reason, and grit, which at first comes off the walls to an annoying extent, even when great care is exercised in construction. This first black is sold, usually at a cheap price, to those who are willing to use a black containing grit. Only after the operation has been carried on for some time, so that everything is warm and in good running order and the loose grit has fallen, can the best results as to quality be obtained.

The lampblack which is thus precipitated can be freed from empyreumatic matter by calcining, as already stated, or by washing with alkali or acid. So far as known, practically none of it is ever washed with alkali or acid, the expense of drying being very material. The handling of black is, in general, a difficult and expensive process, owing to its great bulk and extreme lightness, which cause a great deal of loss and much dirt and disagreeable work. It is more and more the aim of lampblack manufacturers so to conduct their process that the black is calcined in the process of making, at least, to an extent satisfactory to most buyers.

In the case of carbon black, the black when first scraped from the plates is so light that 30 pounds will fill a sugar barrel. When it is considered that the specific gravity of carbon black is about 1.7 (that is, very much heavier than water), it is perceived that 95 per cent of the bulk of black as it comes from the plates is air, and the problem of packing is to separate this black from the air so far as is commercially feasible. This can be done by screw packers, similar to those used for packing flour, but different in detail and run at a very much lower rate of speed; or it can be done by a plunger, lined with sheepskin, the wool side out, worked up and down vertically by a ratchet or screw. An essential element is time. The process of packing carbon black can not be hurried without much loss by the spurting of the black through the air, and many other evils.

As the black comes on the market, a sugar barrel will hold from 75 to 80 pounds. In fact, it is possible to get 80 pounds into a barrel of less than sugar-barrel size, which means that the black has been compressed to about one-third of its original bulk and that still about 88 per cent of its bulk is air. Under these conditions the black is very hard, and many buyers insist on its being packed under less pressure, owing to the consequent greater difficulty of grinding; but its ultimate quality for most uses is not affected by this pressure.

There is still another source of lampblack, to wit, acetylene gas obtained from the refuse of carbide of calcium factories, namely, those grades containing too little carbide of calcium to be merchantable. This acetylene gas possesses the remarkable quality of exploding by itself without the admixture of air, and Jaencke & Schneemann manufactured black by exploding this gas under five atmospheres, either by compression or by an electric spark. The difficulty is, first, that the process is very hard on the apparatus, and, second, that the black thus obtained is very inferior in color and strength to carbon blacks from natural gas. It is essentially a by-product, the supply is very uncertain, and the price is irregular, but always averages much higher than that of carbon black. Therefore, it can only be used where its bluish tinge gives it the preference in certain trades.

"Carbon black" is the trade name given in this country, and to a certain extent abroad, to lampblack made upon the surfaces of metal or stone by direct impact of flame.

The first carbon black made and sold in this country in a commercial way seems to have been produced in the year 1864 by J. K. Wright, of Philadelphia, Pa., for use in the manufacture of printing ink. This industry is, therefore, a comparatively new one in this country, and it certainly never attained any great importance abroad, although it is not possible to state when carbon black was first made in other countries. Mr. Wright revolved sheet-iron cylinders over jets of artificial gas, and the black was removed from the cylinders by stationary scrapers. This process was used by other ink makers also, and a very glossy, high-priced ink, of intense color, was obtained.

These pioneers of the carbon-black industry apparently did not consider the process of sufficient importance to patent it, for the first patent granted in this country was issued December 10, 1867, to A. Millochan, of New York, for a process which proved to be of no value, and it was not until the year 1872 that any process was patented that was subsequently used on a regular commercial scale. The attention of many people, among others of Peter Neff, of Gambier, Ohio, and John Howarth, of Salem, Mass., had been attracted to the fact that large quantities of natural gas going to waste in the gas regions offered a cheap and abundant raw material for this manufacture, and on September 17, 1872, John Howarth received a patent for the manufacture of carbon black from natural carburetted hydrogen gas, claiming the production of

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carbon black from a natural carburetted hydrogen gas issuing from the earth, etc. His plan was to connect the gas well with a gas holder, such as is used in artificial gas works and provided with a blow-off from which might escape the surplus flow of the well not required in the process of manufacture. As the natural pressure of gas in the rock sometimes exceeded 500 pounds on the horizon, from which he derived the supply of his factory, and as there was at that time no method of regulating the flow, this waste of gas was a necessary feature of his enterprise. From the gas holder the gas passed through pipe to ordinary gas jets arranged in the same horizontal plane beneath slabs of soapstone. These slabs of soapstone were provided with holes for ventilating, without which the carbonic-acid gas and other inert products of combustion would have formed a layer about the middle of the slabs and have kept the flame away from the surface, thereby diminishing the yield and impairing the color of the resulting product. Above these slabs of soapstone rose in an arch an iron dome or hood, with a chimney at the top, and in this chimney a damper that could be set to give the right draft. On the slabs rested pans of water closed in and kept cool by a continuous circulation. The edges of this arch descended below the edges of the soapstone slabs and were grooved horizontally. In the grooves ran a scraper that could be pulled to and fro by hand. This scraper removed from time to time the deposited soot which fell into the sheet-iron aprons or troughs which hung from the burner pipe. From these again the black fell through discharge pipes into receptacles which could be changed by hand when full. This was a very crude, clumsy, and inexpensive way of making carbon black, decidedly less advantageous than that previously employed in making black from artificial gas, but, nevertheless, owing to the cheapness of the raw material, the price, which had been $3 to $5, immediately dropped to $2.50, then to $1.50, and shortly after to $1.25 a pound. It is, however, a curious fact that the black from natural gas does not possess all the qualities of that made from artificial gas.

On March 23, 1875, John Howarth received a further patent on a traveling car which hung from rails running lengthwise of the bench or row of slabs, and these rails also held between them the slabs themselves. This car carried a scraper, a shallow frame, and, hanging to that frame on each side, two deep receptacles of sheet iron, which could be detached at will and emptied. These receptacles were joined together over the burners by a narrow arch of sheet iron, just wide enough to allow the apparatus to pass over the single row of burners without striking. The car was drawn by an endless rope passing over pulleys and pulled first in one direction and then in the reverse. The scrapers were held against the plates by wire springs, and were only in contact with the plate when passing toward the end at which the receptacles were removed. The dome was a superfluous adjunct. Cast iron was better than soapstone and there was no need of water cooling. Indeed, Mr. Howarth never used water cooling on a commercial scale. Obviously, its effect would hardly be felt through such a nonconductor as soapstone. The first factory was located at New Cumberland, W. Va. The gas came from what is known as the salt sand, was very rich in carbon, and made an excellent black. The factory was made of wood, and before long it burned down and the business was removed to Saxonburg station, Pa.

In two or three years competition sprang up at Gambier, Ohio, where a small factory was erected by Peter Neff, who had made black by a somewhat similar process for 10 or 12 years. He had as many patents for carbon-black apparatus as all the other inventors put together, but most of them were fantastic and useless. His factory reached an output at one time of 125 pounds a day.

The next important competition was by A. V. Nolen, who, in the year 1879, built a factory at New Cumberland, W. Va., and made black on cast-iron pans holding water. By this time the price of black had gone down to about 60 cents a pound, but, nevertheless, whereas the two pioneers had met with little pecuniary success, Mr. Nolen, by superior ability, made a good deal of money, and bought out the original company.

Various other small factories were started from time to time, but it was not until the year 1883 that any considerable advance was made, when the firm of L. Martin & Co., of Philadelphia, Pa., became interested in a small and struggling enterprise at Fosters Mills, Pa., and there erected five plates 24 feet in diameter, cast in segments and suspended on a central mast, which rotated with them upon a bronze bedplate. Beneath this was fixed a stationary burner of parallel, horizontal iron pipe, 1¼ inches in diameter, branching from a central supply 3¼ inches inside diameter, and this, in turn, connected suitably with the well.

Incredible as it may seem, even at this time, after 10 years of experience, no attempt had been made by the three leading manufacturers to control the flow of gas from the wells, although this was then quite possible with available appliances, and a blazing torch at each gas well, wasting daily millions of feet, was a feature at the principal factories, including that at Fosters Mills, Pa.

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About the same time a factory was started by Samuel Cabot in the adjacent village of Worthington, Pa., at which some efforts were made to confine and economize the gas, but it remained in large part fruitless for some years, owing to the inefficiency of the foreman.

At the factory at Fosters Mills the idea of a traveling box and scraper was discarded and the plan of a horizontally rotated collecting surface was for the first time successfully adopted on a commercial scale. The same principle was adopted at Worthington at about the same time, but failed of success, owing to purely mechanical imperfections. It would seem at first as if the original idea of moving only the scraper box was the correct principle; and yet it is now entirely abandoned, and about two-thirds of all the black that is made to-day is made on surfaces which are moved over a stationary scraper box and stationary burners.

The first decade of the manufacture of carbon black from natural gas on a commercial scale was the time of factories in which the collecting surfaces were arranged in rectangular shapes, placed end to end to form what the workmen call "benches." The details whereby the black was collected, the dimensions of the different parts, and the arrangements of the size of the burners varied in different factories; but four-fifths of all the black made was made on benches, and the rest was made on the external surfaces of rotating cylinders.

The year 1883 brought with it the introduction of large rotating plates, which replaced at Fosters Mills a factory in which benches had been used. A scraper box and scraper was placed radially so that in revolving the scrapers were at right angles to the direction in which the surfaces passed across them. The black was removed by a screw conveyer in the bottom of the scraper box which carried it outward to a longer conveyer, which in turn ran tangential to five plates in a row and carried the black to a rotating bolt, through which it went into the bin. It was then lifted from the bin by hand in large scoops and packed by hand with a screw press, but the black is very light and the handling of it was very dirty, unhealthy work, which involved also considerable loss in raw material. In the earlier factories it had been the habit to brush the black through a fine horizontal sieve by means of brushes rotating on a vertical axis. A bolt revolving on a horizontal axis which discharged the coarser particles of black at one end and allowed only the finer particles to fall through it was a decided improvement.

In the same year A. R. Blood, of Warren, Pa., devised a method in which a small plate about 3 feet in diameter was used. The advantage of this was that no ventilation holes were needed, as in the case of the larger plates, except, however, that this small plate was cast in the form of a ring with an opening in the center. This plate was moved by means of a ratchet at the center. This ratchet was worked by a lever, and this by another lever revolved on a shaft. Every time the shaft revolved the lever would give the plate a little shove, which would move it 1½ inches. Beneath the plate was a scraper in the mouth of a radial hopper, through which the black fell into a longitudinal conveyer running beneath the row of plates. There were 16 plates in a row and 5 rows in the building. The building was of sheet iron on a framework of pipe and angle iron and was pierced with small holes near the bottom to give the needful supply of air. Along the ridgepole was an opening about 30 inches wide, and about 6 inches above this was a little pent roof to prevent the entrance of rain, and through the space between the products of combustion passed. All of these factories used gas jets either of iron or steatite, such as are ordinarily used in houses. There was one factory which used Argand burners, but it did not last many years.

About this same year, 1883, E. R. Blood, the father of A. R. Blood, began to make carbon black by the roller process, using a burner which had a small hole in the point of the tip and which gave a round flame. This method was at first unsatisfactory, because of small yield and the comparatively poor color of the product. Improvements introduced by the successor of Mr. Blood, the Peerless Carbon Black Co., of Pittsburgh, Pa., soon remedied these defects. This company was for many years the only manufacturer of carbon black from natural gas on revolving cylinders, but there are now three factories using this process.

In the second decade the process of making carbon black introduced by A. R. Blood became the most important as to output and total value of black produced. The prices of black fell rapidly and reached 7 cents a pound by the year 1887 and 4 cents a pound by 1889. After this there was a considerable improvement in prices, followed by a further rapid increase in output, and by the close of the second decade the total output had reached about 10,000 pounds a day, worth at that time about 6 cents a pound.

Toward the end of the second decade two new processes began to become an appreciable factor in the total output. The first of these was the process of Mr. Cabot, whereby, under 24-foot plates, similar to those previously mentioned though varying

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somewhat in details, was rotated a burner and black box radially placed. The burner was made up of parallel 1¼-inch pipe inserted in a central supply pipe 3¾ inches in diameter. As first used the radial black box discharged into a hopper placed at the side of the plate by means of a little trapdoor with a lever which was pressed in such a way as to open the trapdoor every time it passed over the hopper; after the discharge the trapdoor closed again by means of a counterpoise. This method of rotating burner was introduced at Worthington about the year 1884, but did not become a commercial success until 1887. The factory changed hands, and the new owner changed the method to that of a central discharge whereby the black was continuously discharged downward by a vertical spout at the inner end of the radial black box into a circular box; thence it went through a hole in the bottom into a long conveyer. By the former method the long conveyer had been tangent to the ring, and by this method it went within 2 feet of the center. A cover was hung above this round box in such a way as to exclude air and rotate with the burners, black-collecting box, etc. The bottom of the vertical spout above alluded to pushed the black in front as it slowly swung around the ring until the black reached the orifice through which it fell. One great advantage of this method was that the black was not exposed to the air. By the former method whenever the box emptied, a cloud of black arose, causing annoyance and much loss of output. As rebuilt, the black was kept under cover and carried to a bolt, also shut in, and raised from beneath this bolt by an elevator into a bin. From this bin it was packed by machinery in either sacks or barrels, always under cover, so that from the time the black was made until it was used by the consumer, it was never touched by hand and was always under cover and protected from all appreciable drafts of air.

The other process above referred to was introduced about the year 1891, at Gallagher, Pa., and consisted of a system of channel beams turned with flat side downward over horizontal rows of stationary burners and black boxes. By a reciprocating mechanism these beams slowly moved back and forth and the black was scraped and removed by a screw conveyer in the usual manner. This black was packed direct without bolting. The chief advantage of this system is the perfection of the surfaces, which are smoother than the surfaces of cast-iron plates.

In the beginning of the third decade of this industry, another attempt was made to manufacture carbon black with the use of petroleum and under a somewhat new principle by evaporating petroleum and burning its vapors through gas burners. The cost of making this black was probably less than that of any other black made from petroleum by the contact process; still it was more than could be realized by its sale. One great difficulty was the formation of adamantine carbon in the black. These particles were so hard that they would scratch glass, and the manufacturer was unable to discover a method of removing them. Since that time there has been no carbon black made from oil on a commercial scale in this country, although there is a small quantity of a very expensive grade made in Europe from what are known as gas oils, heavy oils obtained in the distillation of shale and used chiefly by manufacturers of illuminating gas. No important improvement in making carbon black appeared in the third decade. The output steadily increased and reached 20,000 pounds a day.

The price fluctuated a good deal, the average for the decade (1893–1902) being about 6 cents. The output of black produced with rotating burners and with the reciprocating channel beams very considerably increased. There were also modifications made in the process of the small stationary plate, and the output made on this general principle increased. In 1902 about one-quarter of all the carbon black was made with rotating burners, about one-fifth with reciprocating channel beams, not quite one-half on rotating cast-iron plates, mostly with the smaller sizes, and the rest chiefly with rollers. There was only one factory in existence which operated on the bench principle.

In the year 1899 the construction at the Grantsville, W. Va., factory was begun, which used 24-foot plates, with revolving burners and black box, etc., beneath them. By the end of the third decade, namely, about the year 1902, this had become the largest factory in existence and has been still further increased until it is making about 10,000 pounds of carbon black a day. Possibly a brief description of this factory may be of interest. It lies on the right bank of Little Kanawha River and comprises 113 plates, each 24 feet in diameter and surrounded by protecting rings of corrugated iron 26 feet in diameter. Above these plates is a roof made partly of triangular sheets of sheet iron and partly of rectangular sheets of corrugated iron and reaching about two-thirds of the way to the top of the 16-foot mast on which these plates are hung, leaving, therefore, in the center a space having about one-third the diameter of the plate, through which the products of combustion can escape upward.

These plates are arranged in rows parallel to the river and disposed on two sides of a central avenue which runs from the river to the road, at right angles to both.

The black is collected by long conveyors running through the center of the rows of plates toward the central avenue; here it passes into larger conveyors, which

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bring it to the packing house and elevate it into bins; from them the black is packed partly by sack packers and partly by barrel packers, which work with a plunger.

The black is carried down Little Kanawha River in gasoline boats. Large tanks, containing about a thousand barrels of water, stand on the hillside above the factory, and the factory is adequately piped in every part over an area of about 6 acres, whereby water can be turned on, either for the purpose of putting out fire or for the purpose of knocking black out of the ventilator holes in the rings on which the black is deposited.

These rings are of two patterns: One of them is made with 14 radial arms in the shape of T rails, which support 70 cast-iron plates, 5 between each pair of arms. The other pattern has for each plate 48 segments, 16 in the inner row and 32 in the outer row, which are supported directly by guys. In each case the plate is supported by guys screwed into a cap, which has approximately the shape of a very blunt, truncated cone. This cap rests upon the top of the hollow mast and the joint between the cap and the mast is made good with asbestos board. The mast stands in a bedplate on the upper surface of which is a groove, in which run 1½-inch steel balls. Upon these steel balls rests a casting having 8 horns, which project outward and upward and are fixed in the lower ends of struts made of 2-inch pipe. On the outer end of these struts of 2-inch pipe is an angle casting into which the 2-inch pipe fits and through which a horizontal hole accommodates a horizontal guy rod, attached at the inner end to an octagonal plate, which rotates with the burner around the central mast. On the outer end of these horizontal guy rods are ¾-inch nuts, and by screwing these up the struts can be raised to the correct position, thus regulating the height of the burners beneath the plate. On the face of these angle castings supported by the 2-inch struts is bolted an iron bar, which hangs vertically down from these angle castings, and to this iron bar is attached an angle iron, in which runs the chain that rotates the burners, black box, etc. Against these angle castings is also bolted a horizontal ring, made of bars 4½ by ¼ inch and forming a circle around the plate, and on this ring is supported the gridiron of burner pipe. This gridiron of burner pipe has at its central supply a piece of 3½-inch casing, 22 feet 6 inches long, and this casing, in its turn, is fed with gas by 2½-inch pipes, connected with the help of 4 ells and a union to an octagonal gas box, at the top and bottom of which sit glands. This gas box is fed through holes in the mast. The glands are stuffed with asbestos so that the gas can not escape as the carbon black box revolves around the mast.

The black is removed from the plates by scrapers placed radially to the mast above the box; in the bottom of the box lies a screw conveyer, which in its turn is actuated by a pinion on its inner end, and this pinion engages a bevel fixed to the central mast. Beneath the octagonal plate, to which the horizontal guys are fastened, is bolted a hanger in which turns the shaft of the conveyer which carries the pinion just mentioned. On the inner end of the box the black descends in a vertical 3-inch pipe through the rotating cover into the circular box from which it discharges downward into the long conveyer, which runs tangent to this circular box and 2 feet from the center of the ring.

In the last decade certain new processes have come into use which are, however, only modifications of those mentioned. In one factory, namely, that of the Bristol Oil & Gas Co., of West Virginia, the black is collected on a hollow channel iron, flat beneath, through which a blast of air is blown, with a view of cooling the plates.

The question is often asked whether the heat of the gas used in the manufacture of carbon black is saved or lost, and why. It is always lost, and for the reason that the expense of utilizing this heat would greatly exceed the valve of the power to be obtained. The Grantsville works, producing about 10,000 pounds of black a day, are operated by 5 gas engines, which probably do not consume 50 cents worth of gas a day at the price at which gas is bought at this plant. If these works were in the immediate vicinity of a large city it is probable that it would pay to circulate water underneath them in an immense coil and to heat the neighboring quarter of the city with hot water. Located as they are in a sparsely settled country, 30 miles from the railroad terminus, there is no practical way of saving this heat. Wasteful as this operation seems, it is better than that all of this gas or a great part of it should pass into the atmosphere through the numerous oil wells of the Yellow Creek and other adjoining fields.

Another source of waste in this manufacture is the smoke, which ascends day and night to a very great height in the atmosphere and can sometimes be seen at a distance of 18 miles, but this consists of lampblack rather than carbon black and would probably only sell for 2 or 3 cents a pound if it could be collected, and the task of collecting even one-half of it would probably be much more expensive than the whole maintenance of the factory and its fuel supply.

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The total value of carbon black made in a year would somewhat exceed $1,000,000, and the total annual value of the world's output of lampblack would probably be two or three times as much; but the real importance of these two commodities to humanity is inadequately represented by these figures.

They form the basis of the black printing inks, with which all our printing is done, and they are also largely used in black paints, for stove polish, and for coloring rubber, oilcloth, leather, and many other substances too numerous to mention.

It is rather a curious fact that the use of carbon black and of lampblack are separately defined, and quite sharply defined at that; so that the market price of each commodity fluctuates with little reference to the market price of the other.

Carbon black is much better for black ink, stove polish, and vulcanized rubber. Lampblack is much better for coloring oilcloth, leather, and other forms of rubber, and is much more widely used in paint, although carbon black is better for certain kinds of paint and varnish.

If a buyer is using a black made by the smudge process or by the heating or explosion of hydrocarbon vapors, he does not wish to change and to take the black made on the contact process; and if a buyer is using a black made on the contact process, he can not safely switch over to a black made on the smudge or the explosion process.

The gradual diminution of the margin between the cost of making black and the average selling price goes on, and there seems to be no reason why it should not continue through the present decade. There seems no likelihood, either, of any shortage of carbon black, except from some temporary cause, or of any great and permanent enhancement in the price during the life of any one now living.

CITIES AND TOWNS SUPPLIED WITH NATURAL GAS.

The following list contains the names of cities and towns in the United States which were either wholly or in part supplied with naturals gas in the year 1916:

ALABAMA.

Fayette.
Jasper.

ARKANSAS.

Argenta.
Arkadelphia.
Bauxite.
Benton.
Bierne.
Boughton.
Bryant.
Donaldson.
Emmet.
Fort Smith.
Garland.
Gifford.
Gum Springs.
Gurdon.
Hope.
Hot Springs.
Huntington.
Kibler.
Little Rock.
Mabelvale.
Malvern.
Mansfield.
Perla.
Pine Bluff.
Prescott.
Pulaska Heights.
Ravana.
Sheridan.
South Fort Smith.
Texarkana.
Van Buren.

CALIFORNIA.

Alhambra.
Anaheim.
Arroyo Grande.
Athens.
Avila.
Bakersfield.
Betteravia.
Burbank.
Cement.
Compton.
Cudahy.
Eagle Rock.
Fairfield.
Fellows.
Fullerton.
Gardena.
Garden Grove.
Glendale.
Guadalupe.
Huntington Park.
Lodi.
Long Beach.
Los Angeles.
Los Berros.
Lynwood.
Maricopa.
Moneta.
Nipomo.
Orange.
Orcutt.
Oxnard.
Pasadena.
Pismo.
Placentia.
Redondo Beach.
Sacramento.
San Fernando.
San Gabriel.
San Luis Obispo.
San Pedro.
Santa Ana.
Santa Maria.
Santa Monica.
Santa Paula.
Sawtelle.
South Pasadena.
South Taft.
Stockton.
Suisun City.
Summerland.
Taft.
Torrance.
Tustin.
Tropico.
Venice.
Ventura.
Vernon.
Whittier.
Wilmington.

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ILLINOIS.

Annapolis.
Belleville.
Birds.
Bridgeport.
Carlinville.
Casey.
Collinsville.
Duncanville.
East Chicago.
Eaton.
Edwardsville.
Flat Rock.
Greenville.
Heyworth.
Hutsonville.
Lawrenceville.
Marshall.
Martinsville.
New Hebron.
Oblong.
Olney.
Palestine.
Pinkstaff.
Porterville.
Robinson.
Staunton.
Stoy.
Sumner.

INDIANA.

Adams.
Albany.
Alexandria.
Anderson.
Arcadia.
Atlanta.
Batesville.
Blue Ridge.
Cambridge.
Carmel.
Carthage.
Charlottesville.
Chesterfield.
Cicero.
Clarkesburg.
Connersville.
Converse.
Cowan.
Daleville.
Downeyville.
Dublin.
Dunkirk.
Dunreith.
Eaton.
Elwood.
Fairmount.
Fairview.
Falmouth.
Farmland.
Fortville.
Fountaintown.
Frankton.
Freeport.
Geneva.
Gentryville.
Germantown.
Gowdy.
Greenfield.
Greensburg.
Gwynneville.
Hagerstown.
Hartford City.
Herbst.
Homer.
Honey Creek.
Hope.
Hortonville.
Kennard.
Knightstown.
Kokomo.
La Fontaine.
Letts.
Lewisville.
Loogootee.
Lynn.
McCordsville.
Manilla.
Marion.
Markleville
Maxwell.
Mays.
Middletown.
Mier.
Milford.
Millgrove.
Millhousen.
Milroy.
Milton.
Modoc.
Mohawk.
Montpelier.
Morristown.
Mount Auburn.
Mount Summit.
Muncie.
Newcastle.
New Lisbon.
New Point.
Noblesville.
Normal City.
Oklandon.
Oakland City.
Oakville.
Ovid.
Pendleton.
Pennville.
Portland.
Powers.
Princeton.
Raleigh.
Raysville.
Redkey.
Richmond.
Ridgeville.
Riverside.
Rushville.
St. Paul.
Sandusky.
Sardinia.
Sharpsville.
Shelbyville.
Sheridan.
Shirley.
Spiceland.
Spring Grove.
Springport.
Straughn.
Sullivan.
Sweetsers.
Tipton.
Union City.
Vincennes.
Waldron.
Warrington.
West Liberty.
Westport.
Williamstown.
Winchester.
Windfall.
Winslow.

KANSAS.

Altamont.
Altoona.
Arkansas City.
Atchison.
Atlanta.
Augusta.
Baldwin City.
Bartlett.
Bassett.
Baxter Springs.
Belle Plaine.
Benedict.
Bentley.
Bonner Springs.
Bronson.
Buffalo.
Buffville.
Burden.
Burlington.
Burrton.
Cambridge.
Caney.
Carlyle.
Chanute.
Chautauqua Springs.
Cherokee.
Cherryvale.
Chetopa.
Coffeyville.
Colony.
Columbus.
Cottonwood Falls.
Coyville.
Deerfield.
Derby.
Douglass.
Earleton.
Edgerton.
Edna.
Edwardsville.
Eldorado.
Elk City.
Elk Falls.
Elm.
Elmdale.
Elsmore.
Empire City.
Emporia.
Erie.
Eudora.
Eureka.
Fairhaven.
Fall River.
Fort Scott.
Fredonia.
Galena.
Gardner.
Garnett.
Gas.
Gresley.
Grenola.
Hackney.
Halstead.
Havana.
Haven.
Hepler.
Howard.
Humboldt.
Hunnewell.
Hutchinson.
Independence.
Iola.
Jefferson.
Kansas City.
Labette.
La Harpe.
Lawrence.
Leavenworth.
Lenexa.
Liberty.
Merriam.
Moline.
Moran.
Mound City.
Mound Valley.
Mount Hope.
Mulvane.
Neodesha.
New Albany.
New Salem.
Newton.
Niotaze.
North Altoona.
Olathe.
Osawatomie.
Oswego.

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KANSAS—continued.

Ottawa.
Oxford.
Paola.
Parsons.
Peru.
Pittsburg.
Pleasanton.
Princeton.
Rantoul.
Richmond.
Roper.
Rose.
Savonburg.
Scammon.
Scipio.
Sedan.
Sedgewick.
Shawnee.
Spring Hill.
Stanley.
Strong.
Sycamore.
Thayer.
Tonganoxie.
Topeka.
Turner.
Tyro.
Udall.
Valley Center.
Vilas.
Weir.
Welda.
Wellington.
Wellsville.
Wichita.
Winfield.
Yates Center.

KENTUCKY.

Ashland.
Barbourville.
Bellevue.
Buchanan.
Burning Springs.
Caney.
Cannel City.
Catlettsburg.
Central City.
Chinnville.
Clifton.
Clintonville.
Cloverport.
Cold Spring.
Covington.
Dayton.
Diamond.
Dover.
Estill.
Foster.
Frankfort.
Garrett.
Greenup.
Hazel Green.
Inez.
Kenner.
Kavanaugh.
Lexington.
Louisa.
Louisville.
Ludlow.
Maysville.
Midway.
Monticello.
Mount Sterling.
Newport.
North Middletown.
Paintsville.
Paris.
Pollard.
Rothwell.
Russell.
Salyersville.
Versailles.
Warfield.
Wayland.
West Covington.
West Liberty.
West Point.
Winchester.
Worthington.

LOUISIANA.

Belcher.
Blanchard.
Bossier.
Cedar Grove.
Dixie.
Frierson.
Hosston.
Ida.
Lewis.
Mansfield.
Mooringsport.
Mystic.
Naborton.
Oil City.
Rodessa.
Shreveport.
South Highlands.
Thomason.
Vivian.

MARYLAND.

Barton.
Cumberland.
Deer Park.
Frostburg.
Kitzmillerville.
Klondike.
Loch Lynn.
Lonaconing.
Luke.
Midland.
Mountain Lake Park.
Mount Savage.
Oakland.
Western Port.

MISSOURI.

Carl Junction.
Carterville.
Carthage.
Deerfield.
Duenweg.
Joplin.
Kansas City.
Martin City.
Nevada.
Oronogo.
Parkville.
Prosperity.
St. Joseph.
Webb City.
Weston.

MONTANA.

Glendive.
Havre.

NEW YORK.

Addison.
Akron.
Alden.
Alexander.
Alfred.
Alfred Station.
Allentown.
Almond.
Ambush.
Amherst.
Andover.
Angelica.
Angola.
Armor.
Attica.
Avon.
Baldwinsville.
Batavia.
Belfast.
Belmont.
Bergen.
Blasdell.
Blossom.
Bolivar.
Bowmansville.
Brant.
Bristol.
Bristol Center.
Brocton.
Buffalo.
Caledonia.
Canisteo.
Cattaraugus.
Ceres.
Chautauqua.
Chipmonk.
Churchville.
Clarence.
Clarence Center.
Collins.
Collins Center.
Corfu.
Corning.
Crittenden.
Cuba.
Deer Creek.
Depew.
Dunkirk.
East Aurora.
East Bloomfield.
East Hamburg.
East Pembroke.
Ebenezer.
Eden.
Ellicott.
Elma.

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NEW YORK—continued.

Elmira.
Evans.
Falconer.
Farnham.
Forestville.
Fredonia.
Friendship.
Gangloff.
Gardenville.
Genesee.
Getzville.
Gorham.
Gowanda.
Greenwood.
Hamburg.
Hanover.
Holcomb.
Holland.
Honeoye Falls.
Hornell.
Independence.
Irving.
Jamestown.
Jamieson Road.
Jewettville.
Lacona.
Lackawanna.
Lancaster.
Le Roy.
Lima.
Limestone.
Linwood.
Little Valley.
Millgrove.
Montour Falls.
Moscow.
Mount Morris.
Mumford.
Naples.
North Buffalo.
North Collins.
North Tonawanda.
Obi.
Olean.
Orchard Park.
Otto.
Pavilion.
Perry.
Petrolia.
Phoenix.
Pomfret.
Portland.
Portville.
Pulaski.
Reserve.
Rexville.
Richburg.
Riga.
Ripley.
Rushville.
Salamanca.
Sandy Creek.
Scio.
Sheridan.
Silver Creek.
Southport.
Springville.
Stafford.
Stanards.
Stockton.
Tonawanda.
Town Line.
Versailles.
Warsaw.
Watkins.
Webb Mills.
Wellsville.
West Bloomfield.
West Clarksville.
Westfield.
West Phoenix.
West Seneca.
Wheatland.
Williamsville.
Wyoming.
York.
Zoar.

NORTH DAKOTA.

Lansford.

OHIO.

Academia.
Ada.
Adelphi.
Akron.
Alexandria.
Alger.
Allensville.
Alliance.
Amanda.
Amboy.
Amesville.
Amherst.
Amsterdam.
Andover.
Antioch.
Appleton.
Arcanum.
Arlington.
Ashland.
Ashtabula.
Ashville.
Athens.
Austinburg.
Avery.
Bairdstown.
Baltimore.
Bangs.
Barberton.
Barlow.
Barnesville.
Bartlett.
Basil.
Batesville.
Beach City.
Beallsville.
Beem City.
Bellaire.
Belle Valley.
Belleville.
Bellevue.
Belmont.
Beloit.
Belpre.
Berea.
Bergholz.
Berlin Heights.
Bethany.
Bethesda.
Bettsville.
Beverly.
Bexley.
Birmingham.
Bladensburg.
Bloomdale.
Bloomingburg.
Bloomington.
Bowerston.
Bowling Green.
Bradrick.
Brandon.
Bratenahl.
Bremen.
Bridgeport.
Brilliant.
Brink Haven (Gann)
Brookfield.
Brook Park.
Brookville.
Brownsville.
Buckeye City.
Buckeye Lake.
Buchtel.
Buckingham.
Bucyrus.
Buffalo.
Bullett Park.
Burbank.
Burgoon.
Butler.
Byesville.
Cadiz.
Caldwell.
Cambridge.
Canaanville.
Canal Dover.
Canal Winchester.
Canfield.
Canton.
Carbon Hill.
Cardington.
Carey.
Carroll.
Carrollton.
Castine.
Cedarville.
Celina.
Centerburg.
Chatham.
Chauncey.
Chesapeake.
Chester.
Chesterhill.
Chicago Junction.
Chillicothe.
Chippewa Lake.
Cincinnati.
Circleville.
Clarington.
Claysville.
Clearport.
Cleveland.
Cleveland Heights.
Clintonville.
Clyde.
Coal Grove.
Coal Ridge.
Coal Run.
Coalton.
Cochransville.
Coldwater.
Columbiana.
Columbus.
Conneaut.
Corning.
Corryville.
Coshocton.
Covington.
Crestline.
Creston.
Cridersville.
Crooksville.
Croton.
Cutler.
Cuyahoga Falls.
Cygnet.
Dakes.
Danville.
Dayton.
Deavertown.
Delaware.
Dennison.
Derwent.
Dexter City.
Dover.
Doylestown.
Drakes.
Dresden.
Dudley.
Dunkirk.
East Cleveland.
East Columbus.
East Fultonham.
East Liverpool.
East Palestine.
East Richland.
East Richmond.

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OHIO—continued.

East View.
East Youngstown.
Eaton.
Edison.
Elba.
Eldorado.
Elmore.
Elyria.
Empire.
Enterprise.
Etna.
Euclid.
Euphemia.
Fairfield.
Fairview.
Findlay.
Florence.
Flushing.
Fly.
Forest.
Fort Recovery.
Fostoria.
Franklin.
Frazeysburg.
Fredericktown.
Fremont.
French Creek Avon.
Fulda.
Fultonham.
Gahanna.
Galena.
Galion.
Gallipolis.
Gambier.
Geneva.
Genoa.
Germantown.
Gibsonburg.
Girard.
Glenroy.
Glouster.
Gore.
Grandview.
Granville.
Graysville.
Greenville.
Grogan.
Groveport.
Guysville.
Hallsville.
Hamden.
Hamilton.
Hammondsville.
Hanging Rock.
Hannibal.
Hanover.
Hanoverton.
Harlem Springs.
Harpster.
Harriettsville.
Haydenville.
Hayesville.
Hebron.
Helena.
Hemlock.
Homer.
Homeworth.
Hooker.
Hopedale.
Horns Mills.
Howard.
Hubbard.
Huntsville.
Irondale.
Ironton.
Jackson.
Jackson Center.
Jacksontown.
Jacksonville.
Jefferson.
Jeromesville.
Jerusalem.
Jewett.
Johnstown.
Jolly.
Joy.
Junction City.
Kansas.
Kenmore.
Kent.
Kenton.
Kilgore.
Kilbuck.
Kingston.
Kingsville.
Kirkersville.
Lakeside.
Lakeview.
Lakewood.
Lancaster.
Lathrop.
Laurelville.
Leesville.
Leetonia.
Leonard.
Leroy.
Lewisburg.
Lewisville.
Lexington.
Lima.
Linden.
Lisbon.
Litchfield.
Lock.
Lockville.
Lodi.
Logan.
London.
Lorain.
Lottasburg.
Loudonville.
Lowell.
Lowellville.
Lower Salem.
Ludington.
McArthur.
McConnellsville.
Macksburg.
Malaga.
Malta.
Mansfield.
Maple Heights.
Maria Stein.
Marietta.
Marion.
Martinsburg.
Martins Ferry.
Massillon.
Maumee.
Medina.
Mendon.
Miamisburg.
Middleport.
Middletown.
Mifflin.
Milan.
Millersburg.
Millersport.
Millers Run.
Millertown.
Millwood.
Milo.
Miltonsburg.
Mineral City.
Mingo.
Minster.
Monroe.
Monroeville.
Montezuma.
Morral.
Morristown.
Mount Gilead.
Mount Liberty.
Mount Sterling.
Mount Vernon.
Mount Victory.
Moxahala.
Murray City.
Nashport.
Negley.
Nelsonville.
Neptune.
Nevada.
New Albany.
New Alexandria.
Newark.
New Athens.
New Berlin.
New Beverley.
New Boston.
New Bremen.
Newburgh.
Newburgh Heights.
New Carlisle.
New Castle.
Newcomerstown.
New Hagerstown.
New Knoxville.
New Lexington.
New Matamoras.
New Madison.
New Middletown.
New Paris.
New Philadelphia.
Newport.
New Riegel.
New Springfield.
New Straitsville.
Niles.
North Amherst.
North Baltimore.
North Georgetown.
North Hampton.
North Kingsville.
North Lima.
North Olmsted.
Norwalk.
Norwood.
Nottingham.
Oakfield.
Oakharbor.
Oakwood.
Oberlin.
Orrville.
Osborn.
Osgood.
Outville.
Ozark.
Pataskala.
Pennsville.
Perrysburg.
Perrysville.
Petersburg.
Pickerington.
Piqua.
Pleasant City.
Pleasantville.
Plymouth.
Point Pleasant.
Poland.
Polk.
Pomeroy.
Portage.
Portsmouth.
Proctorville.
Quaker City.
Ravenna.
Red Haw.
Reedurban.
Rendville.
Reno.
Rex Mills.
Reynoldsburg.
Richmond.
Rittman.
Rockbridge.
Rock Creek.
Rockyridge.
Rocky River.
Roseville.
Roxbury.
Rowsburg.
Rural.
Rushville.
Rutland.
St. Clairsville.
St. Henry.
St. Louisville.
St. Marys.
Salem.
Salineville.
Saltpetre.
Sandusky.
Sarahsville.

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OHIO—continued.

Sardis.
Scio.
Sciotoville.
Sebring.
Selma.
Senecaville.
Seville.
Shadyside.
Shaker Heights.
Sharon.
Sharonville.
Sharpsburg.
Shawnee.
Shelby.
Shepard.
Sherodsville.
Shreve.
Sidney.
Simons.
Somerset.
Somerton.
South Charleston.
South Newburgh.
South Olive.
South Pleasantville.
South Zanesville.
Spencer.
Spencer Station.
Spencerville.
Springfield.
Stafford.
Sterling.
Steubenville.
Stewart.
Stockport.
Stoutsville.
Strasburg.
Struthers.
Sugar Creek.
Sugar Grove.
Summerfield.
Summerton.
Summit.
Sunbury.
Sycamore.
Tarlton.
Texas.
Thornville.
Thurston.
Tiffin.
Tippecanoe City.
Tiro.
Toledo.
Toronto.
Tremont City.
Trimble.
Trinway.
Troy.
Uhrichsville.
Union City.
Union Station.
Upper Sandusky.
Urbana.
Utica.
Vanburen.
Vanlue.
Vincent.
Wadsworth
Wapakoneta.
Warner.
Warren.
Warrensville.
Warsaw.
Washington Court House.
Washingtonville.
Waterford.
Waterloo.
Watertown.
Waterville.
Wellington.
Wellston.
Wellsville.
West Alexandria.
West Bedford.
West Carrollton.
Westerville.
West Jefferson.
West Lafayette.
West Manchester.
West Millgrove.
West Park.
West Rushville.
West Salem.
Wheelersburg.
Whipple.
White Cottage.
Wilberforce.
Williamsport.
Woodsfield.
Wooster.
Worthington.
Yellow Springs.
Youngstown.
Xenia.
Zanesville.
Zens City.

OKLAHOMA.

Ada.
Arcadia.
Ardmore.
Avant.
Bartlesville.
Bartlett.
Beggs.
Bigheart.
Bixby.
Blackwell.
Bluejacket.
Boynton.
Braman.
Bristow.
Broken Arrow.
Cameron.
Cathay.
Chandler.
Checotah.
Chelsea.
Choteau.
Claremore.
Cleveland.
Coalton.
Collinsville.
Commerce.
Copan.
Coweta.
Cross.
Cushing.
Davenport.
Dawson.
Delaware.
Depew.
Dewar.
Dewey.
Drumright.
Duncan.
Dustin.
Edmond.
El Reno.
Enid.
Eufaula.
Garnett.
Gotebo.
Guthrie.
Hallett.
Haskell.
Hattonville.
Henryetta.
Hominy.
Hunter.
Inola.
Jenks.
Jennings.
Kellyville.
Kiefer.
Kildare.
Lawton.
Lenapah.
Locust Grove.
Luther.
McAlester.
Markham.
Marlow.
Mazie.
Meeker.
Miami.
Midlothian.
Morris.
Mounds.
Muskogee.
Nardin.
Newkirk.
Nowata.
Ochelata.
Oglesby.
Oilton.
Okewah.
Oklahoma.
Okmulgee.
Oologah.
Osage.
Owasso.
Pawhuska.
Ponca.
Pond Creek.
Porter.
Poteau.
Pryor.
Quinton.
Ramona.
Red Fork.
Red Oak.
Ringling.
Sand-Springs.
Sapulpa.
Schulter.
Shamrock.
Shawnee.
Skiatook.
South Coffeyville.
Spiro.
Stidham.
Stroud.
Terlton.
Tonkawa.
Tulsa.
Turley.
Vinita.
Wagoner.
Wainwright.
Wann.
Welch.
Wellston.
Whiteagle.
Wirt.
Yale.

PENNSYLVANIA.

Adamsburg.
Aliquippa.
Allison Park.
Altoona.
Alum Rock.
Alverton.
Ambridge.
Apollo.
Ardmore.
Argentine.
Arnold.
Austin.
Avalon.
Avonmore.
Axelton.
Baden.

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PENNSYLVANIA—continued.

Baldwin.
Barnes.
Beallsville.
Beaver.
Beaver Falls.
Belle Vernon.
Bellevue.
Bentleyville.
Betula.
Bingham.
Blackstown.
Blacksville.
Blairs Corners.
Blairsville.
Bloomster.
Bluff.
Bolivar.
Boston.
Bowerton.
Boyers.
Bradford.
Bradys Bend.
Branchton.
Brockport.
Brockwayville.
Brookston.
Brookville.
Brownsville.
Bruceton.
Bruin.
Bryant.
Buena Vista.
Buffalo.
Bullion.
Bully Hill.
Burdette.
Burgettstown.
Burnsville.
Burtville.
Butler.
Cabot.
Caledonia.
California.
Callensburg.
Callery.
Campbelltown.
Candor.
Canonsburg.
Carbon Center.
Carlo.
Carnegie.
Carnot.
Carrick.
Carrolltown.
Castle Shannon.
Cecil.
Centerville.
Ceres.
Charleroi.
Chicora.
Church.
Clairton.
Clarendon.
Clarendon Boro.
Clarington.
Clarion.
Clarksburg.
Clarksville.
Claysville.
Clermont.
Clintonville.
Coal Valley.
Cochranton.
Colegrove.
Coleville.
Colona.
Connellsville.
Conoquenessing.
Conway.
Cooksburg.
Cooperstown.
Coraopolis.
Corry.
Corsica.
Coryville.
Costello.
Coudersport.
Courtney.
Cowanesque.
Cowansville.
Craigsville.
Cresson.
Crosby.
Curllsville.
Dahoga.
Darlington.
Davistown.
Dawson.
Dayton.
Deemston.
Delmont.
Dempseytown.
Derrick City.
Derry.
Donora.
Dorseyville.
Dubois.
Duke Center.
Dunbar.
Dunkard.
East Brady.
East Hickory.
East McKeesport.
Easton.
East Sharon.
East Springfield.
East Titusville.
Eclipse.
Edgewood.
Edgeworth.
Edinburg.
Eidenau.
Elbon.
Eldersville.
Eldora.
Eldorado.
Eldred.
Elizabeth.
Elkland.
Ellwood City.
Emlenton.
Emporium.
Emsworth.
Endeavor.
Enon Valley.
Enterprise.
Erie.
Evans City.
Export.
Fairhope.
Fairmount City.
Fairhaven.
Fairview.
Falls Creek.
Farrell.
Fayette City.
Fern.
Finleyville.
Fisher.
Florence.
Ford City.
Fosters Mills.
Foxburg.
Franklin.
Fredonia.
Freedom.
Freeport.
Frogtown.
Fryburg.
Gaines.
Galeton.
Garards Fort.
Garland.
Gastonville.
Genesee.
Geneva Hill.
Gibsonton.
Gill Hall.
Gilmore.
Ginger Hill.
Girard.
Glade Run.
Glassport.
Glendale.
Glenfield.
Glenhazel.
Glen Osborne.
Glenwillard.
Grand Valley.
Graysville.
Great Belt.
Greenfield.
Greenock.
Greensboro.
Greensburg.
Greenville.
Gresham.
Grove City.
Guffey.
Guitonville.
Hackett.
Hadley.
Haffey (Milltown).
Halsey.
Harmony.
Harpers Corners.
Harrison City.
Harrison Valley.
Harrisville.
Hawthorn.
Haysville.
Hazel Hurst.
Heidelburg.
Hendersonville.
Henrys Bend.
Herman.
Hickory.
Highland.
Hilliards.
Hillsville.
Holbrook.
Hollidaysburg.
Homer.
Homer City.
Hooker.
Hopwood.
Houston.
Hydetown.
Imperial.
Indiana.
Industry.
Ingomar.
Instanter.
Irvineton.
Irwin.
Jackson Center.
Jacksonville.
James City.
Jamestown.
Jeannette.
Jefferson.
Johnetta.
Johnsonburg.
Johnstown.
Jollytown.
Juniata.
Kane.
Kane Boro.
Kane City.
Kanesholm.
Karns City.
Kaylor.
Keisters.
Kelletsville.
Khedive.
Kingsville.
Kinzua.
Kittanning.
Knox.
Knoxville.
Kushequa.
Lamartine.
Lamont.
Langloth.
Larabee.
Larimer.
Latrobe.
Lawrenceville.
Leechburg.
Leeper.
Leesburg.
Leetsdale.
Lewis Run.
Lickingville.

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PENNSYLVANIA—continued.

Ligonier.
Limestone.
Livermore.
Logans Ferry.
Loretta.
Lucinda.
Ludlow.
McClellandtown.
McDonald.
McKeesport.
McKees Rocks.
McKinley.
Manor.
Manorville.
Mapleshade.
Mapletown.
Marble.
Marianna.
Marienville.
Mars.
Marvindale.
Marwood.
Masontown.
Matildaville.
Mayburg.
Mayport.
Meadow Lands.
Meadville.
Mechanicsville.
Mercer.
Middle Fork.
Midland.
Millers Eddy.
Millport.
Monaca.
Monaca Heights.
Monessen.
Monongahela.
Monroeville.
Monterey.
Mount Alton.
Mount Jewett.
Mount Morris.
Mount Oliver.
Mount Pleasant.
Murrysville.
Myonia.
Natrona.
Nedskey.
Nelson.
New Bethlehem.
New Brighton.
New Castle.
New Eagle.
New Florence.
New Freeport.
New Galilee.
New Kensington.
New Mayville.
New Salem.
New Sheffield.
New Stanton.
Newton.
Newtown Mills.
New Wilmington.
Noblestown.
North Bessemer.
North Blackville.
North East.
North Girard.
North Irwin.
North Warren.
Norwich.
Oakdale,
Oakland.
Oak Ridge.
Oil City.
Ormsby.
Osceola.
Osgood.
Oswayo.
Otto.
Parker.
Parkers Landing.
Petersville.
Petroleum Center.
Petrolia.
Philipston.
Pittsburgh.
Pittsfield.
Pleasantville.
Plummer.
Point Marion.
Polk.
Pollock.
Portage.
Port Allegany.
Port Barnett.
Porter.
Portersville.
Portland Mills.
Poseytown.
Potter Brook.
Prentice.
Primrose.
Prospect.
Punxsutawney.
Queen.
Queenstown.
Rankin.
Ratigan.
Raymilton.
Red Fork.
Redman.
Red Rock.
Reidsburg.
Renfrew.
Reno.
Reynoldsville.
Richmond.
Ridgway.
Rimer.
Rimer Hill.
Rimersburg.
Rixford.
Rochester.
Rockland.
Rockmere.
Rockygrove.
Rogersville.
Rolfe.
Roscoe.
Roseville.
Roulette.
Rouseville.
Rural Valley.
Russell.
Rynd Farm.
St. Marys.
St. Petersburg.
Sabinsville.
Salem.
Salina, Venango County.
Salina, Westmoreland County.
Saltsburg.
Sandy Lake.
Sankertown.
Saxonburg.
Scottdale.
Semples.
Seneca.
Sergeant.
Sewickley.
Sharon.
Sharon Center.
Sharpsville.
Shawmut.
Sheffield.
Shinglehouse.
Shinglehouse Boro.
Shippenville.
Sigel.
Sligo.
Slippery Rock.
Smethport.
Smiths Ferry.
Snowden.
South Brownsville.
South Heights.
South Jeannette.
South Sharon.
Spring Church.
Stoneboro.
Stoneham.
Straight.
Strattonville.
Sturgeon.
Sugar Creek.
Summerville.
Summit.
S. W. Greensburg.
Swissvale.
Tarentum.
Tarrs.
Taylorstown.
Tidal.
Tidioute.
Tiona.
Tionesta.
Titusville.
Townville.
Troutman.
Turtle Creek.
Tylersburg.
Ulysses.
Uniontown.
Unity.
Upper Middletown.
Utica.
Valencia.
Valley Station.
Van.
Vanderbilt.
Vandergrift.
Vanport.
Venango Station (P. R. R.).
Venetia.
Venus.
Verona.
Video.
Volant.
Walkers Mills.
Waltersburg.
Warren.
Warren Boro.
Washington.
Waters.
Waynesburg.
Webster.
West Alexander.
West Branch.
West Elizabeth.
West End Boro.
Westfield.
West Freedom.
West Hickory.
Westline.
West Middlesex.
West Middletown.
West Monongahela.
West Monterey.
Westmoreland City.
West Newton.
West Reynoldsville.
West Sunbury.
West Winfield.
Wetmore.
Wheatland.
Whiskerville.
Whitetown.
Wick.
Widnoon.
Wilcox.
Wilkinsburg.
Wilson.
Wireton.
Woodlawn.
Worthington.
Youngsville.
Youngwood.
Zelienople.

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SOUTH DAKOTA.

Fort Pierre.
Pierre.

TEXAS.

Abilene.
Albany.
Alvord.
Arlington.
Atlanta.
Baird.
Bangs.
Bellevue.
Bloomburg.
Bowie.
Bridgeport.
Byers.
Cass.
Cisco.
Clyde.
Corsicana.
Crowther.
Dallas.
Dalworth.
Decatur.
Denison.
Denton.
Eagle Ford.
Electra.
Fort Worth.
Gainesville.
Grand Prairie.
Groesbeck.
Henrietta.
Highland Park.
Irving.
Kirk.
Laredo.
Leigh.
McKinney.
Marshall.
Mart.
Mexia.
Moran.
Niles.
Petrolia.
Polytechnic.
Putnam.
Queen City.
Rhome
Richland.
Santa Anna.
Sherman.
Sunset.
Teague.
Tehuacana.
Texarkana.
Thurber.
Trinity Heights.
Waco.
Whitesboro.
Wichita Falls.
Wortham.

WEST VIRGINIA.

Adamston.
Adrian.
Alma.
Alvord.
Amma.
Arvilla.
Auburn.
Bannister.
Barboursville.
Barrackville.
Bayard.
Belington.
Belmont.
Bens Run.
Benwood.
Bepson.
Beraman.
Berea.
Bigbend.
Big Creek.
Big Isaac.
Big Springs.
Blacksville.
Blaine.
Blue Creek.
Blueville.
Boothsville.
Branchland.
Bridgeport.
Briscoe.
Bristol.
Broad Oaks.
Brookville.
Buckhannon.
Buffalo.
Burning Springs.
Burnsville.
Burton.
Cairo.
Calif Mines.
Cameron.
Cannelton.
Cedargrove.
Center Point.
Centerville.
Ceredo.
Charleston.
Chelyan.
Chester.
Clarington.
Clarksburg.
Clendenin.
Coalburg.
Coburns Creek.
Coger.
Colfax.
Colliers.
Columbia Mines.
Corinth.
Crawford.
Creston.
Crown Hill.
Culloden.
Danville.
Davis.
Davissons Run.
Daybrook.
Deanville.
Dobbin.
Dunbar.
Eastbank.
East Lynn.
Edgewood.
Elizabeth.
Elkins.
Elk Garden.
Elk View.
Ellenboro.
Elm Grove.
Elm Run.
Enterprise.
Eris.
Eureka.
Fairmont.
Fairview.
Farmington.
Farnum.
Finch.
Fink.
Flat Woods.
Flemington.
Follansbee.
Fort Gay.
French Creek.
Frenchton.
Friendly.
Fulton.
Gandeeville.
Gassaway.
Gaston.
Gay.
Glen Dale.
Glen Easton.
Glen Falls.
Glenova.
Glenwood.
Glenville.
Glovergap.
Goose Creek.
Gormania.
Gould.
Grafton.
Grantsville.
Grasselli.
Griffithsville.
Hamlin.
Handley.
Hannahdale.
Hansford.
Harrisville.
Hartley (Munday P. O.).
Haymond Heights.
Haywood.
Heaters.
Henry.
Hepzibah.
Horner.
Hundred.
Huntington.
Hurricane.
Hutchinson.
Industrial.
Ireland.
Jacksonburg.
Janelew.
Jarvisville.
Johnstown.
Jordan Creek.
Kelly Hill.
Kempton.
Kenova.
Kermit.
Keyser.
Kygar.
Leatherwood.
Lima.
Littleton.
Logan.
Longacre.
Lost Creek.
Loudenville.
Loveland.
Lumberport.
McMechen.
Madison.
Mahone.
Mammoth.
Mannington.
Martha.
Meadowbrook.
Metz.
Middlebourne.
Miletus.
Milton.
Monongah.
Montgomery.
Montpelier.
Monticello Add.
Morgantown.
Moundsville.
Mount Clare.
Mount Zion.
Murphytown.
Myra.
Newark.
New Cumberland.
New Fairground.
New Martinsville.
North View.

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WEST VIRGINIA—continued.

Norwood Park.
Ogdin.
Ona.
Orlando.
Paden City.
Palestine.
Parkersburg.
Parsons.
Patterson.
Peel Tree.
Pennsboro.
Peoria.
Perry Mines.
Petroleum.
Peytona.
Philippi.
Piedmont.
Pine Grove.
Pleasant Valley.
Poca.
Point Comfort.
Point Pleasant.
Pratt.
Proctor.
Pruntytown.
Pullman.
Racine.
Ravenswood.
Reedy.
Ripley.
Riverside Addition.
Roanoke.
Rockcave.
Rockford.
Rowlesburg.
St. Albans.
St. Marys.
Salem.
Sandyville.
Schultz.
Sedalia.
Seth.
Sherrard.
Shiloh.
Shinnston.
Shirley.
Shrewsbury.
Silverton.
Simpson.
Sistersville.
Smithburg.
Smithers.
Smithfield.
Smithville.
South Buckhannon
Spencer.
Spring Hill.
Star City.
Stealey Heights.
Summit Park.
Sutton.
Tanner.
Terra Alta.
Thomas.
Thornton.
Three Mile.
Tin Plate.
Troy.
Tyler City.
Union Heights.
Volcano.
Walgrove.
Walkersville.
Wallace.
Walton.
Ward.
Warwood.
Waverly.
Wayne.
Wellsburg.
West Fork.
West Hamlin.
Weston.
West Union.
Wheeling.
Wileyville.
William.
Williamson.
Williamstown.
Wilsonburg.
Woodlawn.
Woodsdale.
Woodville.
Worthington.
Wyatt.

WYOMING.

Basin.
Byron.
Greybull.
Lovell.

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PETROLEUM.[1]

By JOHN D. NORTHROP.

INTRODUCTION.

The supremacy maintained by the United States since 1859 in the petroleum industry of the entire world lends unusual interest to even the normal trend of events in all phases of that industry in this country. Under the abnormal world conditions resulting from the great war the course of that industry in the country that produces, refines, and markets two-thirds of the world's current supply of petroleum is of especial interest, an interest that becomes world-wide and vital when the relation of petroleum and its derivatives to the conduct of modern warfare is fully appreciated.

Since the beginning of the European conflict petroleum has been considered a war munition of the first order, and its precedence has increased mightily with the subsequent development (1) of necessary means for the rapid transport of men, ammunition, and food on land; (2) of submarine warfare and its complement, submarine chasing, on the sea; (3) but chiefly of aerial warfare and its vast fleets of scout planes, battle planes, and observation planes.

The foreign demands for motor fuels and lubricants resulting from these developments and the increased domestic demand for these same products emanating from the impulse given to all forms of industry in this country by enlarged requirements abroad for raw materials and finished products of all kinds have brought about a condition of pronounced stimulation that has affected every phase of the domestic industry.

The progress of this stimulus from the marketing of the refined products back through the refining, transporting, and purchasing of the crude oil to the actual producers, the varied cross currents that have tended to impede and to accelerate its transmission, and the far-reaching effects it has already wrought throughout the industry are matters of fascinating interest to the student of petroleum affairs and of more than casual interest to the average man. As these topics have already been discussed elsewhere,[2] their mention will suffice in this report, which is primarily merely a review of the production phase of the petroleum industry of the United States in 1916. As such this report consists chiefly of statistics of petroleum marketed, wells drilled, etc., in the oil fields of this country; but it includes a discussion of the significant developments resulting from activity in

[1] The statistical tables presented in this chapter are the work of Miss A. B. Coons, statistical clerk, with the exception of those relating to imports and exports, which were compiled from the records of the Bureau of Foreign and Domestic Commerce by J. A. Dorsey.

[2] Northrop, J. D., Petroleum: U. S. Geol. Survey Bull. 666-DD. 1917; War's effect upon oil industry of the United States: New York Evening Post, Aug. 31, 1917, oil industry supplement, pp. 7-8.

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drilling in each important district. Brief notes on the trend of the petroleum industry in other countries so far as conditions can be ascertained are appended. The present chapter is the thirty-fifth in the series of statistical records of the petroleum industry issued by the Geological Survey since its organization in 1879.

General conditions.—The country-wide activity in the quest for petroleum inherited from 1915 continued with increasing vigor during the early months of 1916 and was attended with such success in new production both from areas whose development had been curtailed during the period of Cushing's domination of the oil industry and from strictly new territory as to threaten overproduction in midsummer. That the lessons of the preceding year had not passed unheeded was evinced by the prompt repression of activity in drilling in all fields coincident with the first reduction in runs of crude oil by the pipe-line companies in the Mid-Continent field on July 8, which preceded the posting of the first reduction in market quotations for oil at the wells by only two weeks. As a consequence of this prompt action on the part of the producers and of the steadily growing demand for crude oil by the refiners the market depression was only moderate and the period of threatened overproduction was brief. It terminated, in fact, before the end of September, and during the closing months of 1916 activity in drilling attained normal proportions in all the old fields and was renewed in countless localities where petroleum was believed to exist.

A deterring influence on drilling operations that made itself felt during the last months of 1916 was the increased cost of many essential supplies, and more ominously the increasing scarcity of such requisites as casing, pipe, and wire rope, without which wells can be neither drilled nor pumped. This scarcity which portends a serious famine in the near future is accounted for by the enormous demand for iron and steel in the obvious war-time industries that has reduced the commercial supply and delayed the delivery of the necessary materials from which the requisites for drilling are manufactured.

Prices.—Throughout the country prices for crude petroleum at the wells averaged decidedly higher in 1916 than in 1915, and in most of the fields they exceeded the average prices obtained in any other year since the petroleum industry of the United States was in its infancy. The ascending scale of prices inherited from 1915 advanced steadily during the first three months of 1916, quotations on all grades attaining in March record levels that were maintained with minor exceptions until the later part of July, when a general retrogression began. This culminated near the end of August, but was succeeded near the end of September by an upward movement that before the end of the year established new records for practically all grades of eastern and Mid-Continent oil, except "Oklahoma-Kansas" grade, and materially improved quotations on that grade.

In California where markets for crude oil are unaffected by the influences that direct the course of eastern and Mid-Continent oils price revisions in 1916, as discussed more specifically on page 838, were numerous and all upward.

Pennsylvania grade, whose course is typical of price movements in the eastern fields, opened the year at $2.25 a barrel and advanced steadily to a high level of $2.60 a barrel on March 17. This level was

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maintained until July 29, when the retrograde movement first affected eastern oils. Successive reductions brought quotations on the oil to $2.30 a barrel on August 15, a price that remained in force until September 28, when the upward movement began that restored the $2.60 quotation on October 20 and advanced it to $2.85 a barrel before the end of December.

Oklahoma-Kansas grade followed a course that was broadly similar. Opening at $1.20 a barrel the price of this grade of oil reached its high level of $1.55 on March 14. Its decline began on July 24 and and culminated with a minimum of $0.90 on August 26. Its subsequent recovery began on November 29, and its closing price was $1.40 a barrel.

Significant developments.—As might be inferred from the stimulation of attractive markets, not only for crude petroleum but for refined products as well, the year 1916 was one of notable progress in the development of the petroleum industry as a whole.

In the production branch the organization of new and powerful corporations and the continued expansion of the corporations that already existed was the principal feature of the year's developments. The consolidation of a great number of individual producing, transporting, and refining interests into such powerful organizations as the Empire Gas & Fuel Co., Empire Pipe Line Co., and Empire Refining Co., Cosden & Co., Sinclair Oil & Refining Corporation, Oklahoma Producing & Refining Co., and Pan American Petroleum & Transport Co., and the aggressive expansion of such existing corporations as the Tidewater Oil Co., Ohio Cities Gas Co., Royal Dutch Co., Midwest Refining Co., and Magnolia Petroleum Co., to include important propreties formerly not owned by them, tended toward stabilization in the industry. This will be of immense value to the individual producer, as it will afford him a choice of markets for his product and will also place the domestic industry in a stronger position than otherwise to bid for greater world markets after the war.

The enormous and increasing demand for gasoline and lubricating oils both at home and abroad stimulated the refiner of petroleum to further efforts looking to the development of processes for increasing the recovery of the lighter products of distillation from all grades of crude oil. The Burton process, controlled by the Standard Oil Co. of Indiana, maintained its premier position in this line of development, its use being widely extended among refiners of the Standard Oil group during 1916.

With regard to litigation between the Federal Government and petroleum operators on lands withdrawn from all forms of entry and included in the petroleum reserves by Executive order, progress was recorded in 1916 in the decision[1] of Judge Bledsoe in the McCutchen case, announced in August, in the district court of the United States in the southern district of California.

This decision establishes the point that any locator who was on withdrawn lands at the date of their withdrawal and was then with "due diligence" prosecuting work toward a discovery of oil was unaffected by that order and had a valid location and could proceed to enter or proceed to a discovery and thereby perfect his right to

[1] United States v. McCutchen, 234 Fed., 702.

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the mineral claim, but that a locator not in possession or who was not with "due diligence" prosecuting his work toward discovery on the date of a withdrawal was not protected by the order. It establishes further that a person or locator deeming the withdrawal order entirely invalid can neither begin operations nor resume lapsed operations looking to the discovery of oil on his claim, for the reason that the land by reason of the order is no longer open to entry or claim and as between him and the Government any subsequent effort of his could not divest the Government of its title.

Another important decision[1] bearing on litigation involving withdrawn lands was announced in October by Judge Trieber, in the United States Circuit Court of Appeals, eighth district. This decision affirms that a citizen of the United States, who in good faith enters upon unwithdrawn public land for the purpose of discovering oil or gas and takes possession of the land by placing a caretaker thereon while he is taking proper steps to obtain material necessary for the work of constructing camps, enters into contracts for the drilling of wells, acts as expeditiously as possible in erecting a camp and preparing for drilling, expends money and enters into contracts whereby he becomes liable for sums of money to prosecute work resulting from the discovery of oil or gas, and as soon as it is possible in the exercise of proper diligence, begins the work of drilling and continues it diligently and expeditiously until oil is discovered in commercial quantities, is within the protection of the proviso of the act of Congress known as the Pickett Act, passed June 25, 1910 (36 Stat., 847), as against a withdrawal order approved by the President before such discovery is actually made.

Though the matter was agitated in Congress, no legislation was enacted in 1916 providing for the development of public lands withdrawn from entry and included by Executive order in petroleum reserves.

PRODUCTION.

The quantity of petroleum actually brought to the surface in the various oil fields of the United States in 1916 is not susceptible of accurate determination by the system of voluntary reports from oil producers on which the United States Geological Survey must depend. The incomplete data at hand permit only an estimate of the quantity of oil produced in excess of that marketed in any year. According to the best information available this quantity amounted to not less than 6,500,000 barrels in 1916. Addition of these figures to those of petroleum marketed gives a total of 307,267,000 barrels as the approximate output of the oil wells in this country in 1916.

[1] United States v. Grass Creek Oil & Gas Co., 236 Fed., 481.

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MARKETED PRODUCTION.

GENERAL STATEMENT.

The quantity of petroleum marketed from the oil fields of the United States in 1916, which amounted to 300,767,158 barrels of 42 gallons each, establishes a new record of petroleum output in this country that is nearly 7 per cent greater than the former maximum yield of 281,104,104 barrels, established in 1915.

The average price received at the wells for this oil was $1.10 a barrel, and the total market value of the output was $330,899,868, a gain of 46 cents in average unit price and of $151,436,978, or 84 per cent, in gross market value, compared with 1915.

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Petroleum marketed in the United States.

Year.	Pennsylvania and New York.	Ohio.	West Virginia.	California.	Kentucky and Tennessee.	Colorado.	Indiana.	Illinois.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
1859	2,000	.....	.....	.....	.....	.....	.....	.....
1860	500,000	.....	.....	.....	.....	.....	.....	.....
1861	2,113,609	.....	.....	.....	.....	.....	.....	.....
1862	3,056,690	.....	.....	.....	.....	.....	.....	.....
1863	2,611,309	.....	.....	.....	.....	.....	.....	.....
1864	2,116,109	.....	.....	.....	.....	.....	.....	.....
1865	2,497,700	.....	.....	.....	.....	.....	.....	.....
1866	3,597,700	.....	.....	.....	.....	.....	.....	.....
1867	3,347,200	.....	.....	.....	.....	.....	.....	.....
1868	3,646,117	.....	.....	.....	.....	.....	.....	.....
1869	4,215,000	.....	.....	.....	.....	.....	.....	.....
1870	5,260,745	.....	.....	.....	.....	.....	.....	.....
1871	5,205,234	.....	.....	.....	.....	.....	.....	.....
1872	6,293,194	.....	.....	.....	.....	.....	.....	.....
1873	9,893,786	.....	.....	.....	.....	.....	.....	.....
1874	10,926,945	.....	.....	.....	.....	.....	.....	.....
1875	8,787,514	.....	.....	.....	.....	.....	.....	.....
1876	8,968,906	31,763	120,000	12,000	.....	.....	.....	.....
1877	13,135,475	29,888	172,000	13,000	.....	.....	.....	.....
1878	15,163,462	36,179	180,000	15,227	.....	.....	.....	.....
1879	19,685,176	29,112	180,000	19,358	.....	.....	.....	.....
1880	26,027,631	38,940	179,000	40,552	.....	.....	.....	.....
1881	27,376,509	33,867	151,000	99,862	.....	.....	.....	.....
1882	30,053,500	39,761	128,000	128,636	.....	.....	.....	.....
1883	23,128,389	47,632	126,000	142,857	4,755	.....	.....	.....
1884	23,772,209	90,081	90,000	262,000	4,148	.....	.....	.....
1885	20,776,041	661,580	91,000	325,000	5,164	.....	.....	.....
1886	25,798,000	1,782,970	102,000	377,145	4,726	.....	.....	.....
1887	22,356,193	5,022,632	145,000	678,572	4,791	76,295	.....	.....
1888	16,488,668	10,010,868	119,448	690,333	5,096	297,612	.....	.....
1889	21,487,435	12,471,466	544,113	303,220	5,400	316,476	33,375	1,460
1890	26,458,208	16,124,656	492,578	307,360	6,000	368,842	63,496	900
1891	33,009,236	17,740,301	2,406,218	323,600	9,000	665,482	136,634	675
1892	28,422,377	16,362,921	3,810,086	385,049	6,500	824,000	698,068	521
1893	20,314,513	16,249,769	8,445,412	470,179	3,000	594,390	2,335,293	400
1894	19,019,990	16,792,154	8,577,624	705,969	1,500	515,746	3,688,666	300
1895	19,144,390	19,545,233	8,120,125	1,208,482	1,500	438,232	4,386,132	200
1896	20,584,421	23,941,169	10,019,770	1,252,777	1,680	361,450	4,680,732	250
1897	19,262,066	21,580,515	13,090,045	1,903,411	322	384,934	4,122,356	500
1898	15,948,464	18,738,708	13,615,101	2,257,207	5,568	444,383	3,730,907	380
1899	14,374,512	21,142,108	13,910,630	2,642,095	18,280	390,278	3,848,182	380
1900	14,559,127	22,362,730	16,195,675	4,324,484	62,259	317,385	4,874,392	200
1901	13,831,996	21,648,083	14,177,126	8,786,330	137,259	460,520	5,757,086	250
1902	13,183,610	21,014,231	13,513,345	13,984,268	185,331	396,901	7,480,896	200
1903	12,518,134	20,480,286	12,899,395	24,382,472	554,286	483,925	9,186,411	.....
1904	12,239,026	18,876,631	12,644,686	29,649,434	998,284	501,763	11,339,124	.....
1905	11,554,777	16,346,660	11,578,110	33,427,473	1,217,337	376,238	10,964,247	181,084
1906	11,500,410	14,787,763	10,120,935	33,098,598	1,213,548	327,582	7,673,477	4,397,050
1907	11,211,606	12,207,448	9,095,296	39,748,375	820,844	331,851	5,128,037	24,281,973
1908	10,584,453	10,858,797	9,523,176	44,854,737	*f* 727,767	379,653	3,283,629	33,686,238
1909	10,434,300	10,632,793	10,745,092	55,471,901	*f* 639,016	310,861	2,296,086	30,898,339
1910	9,848,500	9,916,370	11,753,071	73,010,560	*f* 468,774	239,794	2,159,725	33,143,362
1911	9,200,673	8,817,112	9,795,464	81,134,391	*f* 472,458	226,926	1,695,289	31,317,038
1912	8,712,076	*a* 8,969,007	12,128,962	*g* 87,272,593	*f* 484,368	206,052	970,009	28,601,308
1913	8,865,493	8,781,468	11,567,299	97,788,525	*f* 524,568	188,799	956,095	23,893,899
1914	9,109,309	8,536,352	9,680,033	99,775,327	*f* 502,441	222,773	1,335,456	21,919,749
1915	8,726,483	7,825,326	9,264,798	86,591,535	*f* 437,274	208,475	875,758	19,041,695
1916	8,466,481	7,744,511	8,731,184	90,951,936	1,203,246	197,235	769,036	17,714,235
	771,373,177	448,331,841	278,228,797	918,817,030	10,736,490	11,054,853	104,468,594	269,082,546

a Includes the production of Michigan.
b Includes the production of Oklahoma.
c Included with Kansas.
d Estimated.
e Includes production of Utah.

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1859–1916, in barrels of 42 gallons.

Kansas.	Texas.	Missouri.	Oklahoma.	Wyoming.	Louisiana.	Montana.	United States.	Total value.	Year.
Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*		
.....	.....	.....	.....	.....	.....	.....	2,000	$32,000	1859
.....	.....	.....	.....	.....	.....	.....	500,000	4,800,000	1860
.....	.....	.....	.....	.....	.....	.....	2,113,609	1,035,668	1861
.....	.....	.....	.....	.....	.....	.....	3,056,600	3,209,525	1862
.....	.....	.....	.....	.....	.....	.....	2,611,309	8,225,663	1863
.....	.....	.....	.....	.....	.....	.....	2,116,109	20,896,576	1864
.....	.....	.....	.....	.....	.....	.....	2,497,700	16,459,853	1865
.....	.....	.....	.....	.....	.....	.....	3,597,700	13,455,398	1866
.....	.....	.....	.....	.....	.....	.....	3,347,300	8,066,993	1867
.....	.....	.....	.....	.....	.....	.....	3,646,117	13,217,174	1868
.....	.....	.....	.....	.....	.....	.....	4,215,000	23,730,450	1869
.....	.....	.....	.....	.....	.....	.....	5,260,745	20,503,754	1870
.....	.....	.....	.....	.....	.....	.....	5,205,234	22,591,180	1871
.....	.....	.....	.....	.....	.....	.....	6,293,194	21,440,503	1872
.....	.....	.....	.....	.....	.....	.....	9,893,736	18,100,464	1873
.....	.....	.....	.....	.....	.....	.....	10,926,945	12,647,527	1874
.....	.....	.....	.....	.....	.....	.....	8,787,514	7,368,133	1875
.....	.....	.....	.....	.....	.....	.....	9,132,669	22,982,822	1876
.....	.....	.....	.....	.....	.....	.....	13,350,363	31,788,566	1877
.....	.....	.....	.....	.....	.....	.....	15,396,868	18,044,520	1878
.....	.....	.....	.....	.....	.....	.....	19,914,146	17,210,708	1879
.....	.....	.....	.....	.....	.....	.....	26,286,123	24,600,638	1880
.....	.....	.....	.....	.....	.....	.....	27,661,238	25,448,339	1881
.....	.....	.....	.....	.....	.....	.....	30,349,897	23,631,165	1882
.....	.....	.....	.....	.....	.....	.....	23,449,633	25,790,252	1883
.....	.....	.....	.....	.....	.....	.....	24,218,438	20,595,966	1884
.....	.....	.....	.....	.....	.....	.....	21,858,785	19,198,243	1885
.....	.....	.....	.....	.....	.....	.....	28,064,841	19,996,313	1886
.....	.....	.....	.....	.....	.....	.....	28,283,483	18,877,094	1887
.....	.....	.....	.....	.....	.....	.....	27,612,025	17,947,620	1888
500	48	20	.....	.....	.....	.....	35,163,513	26,963,340	1889
1,200	54	278	.....	.....	.....	.....	45,823,572	35,365,105	1890
1,400	54	25	30	.....	.....	.....	54,292,655	30,526,553	1891
5,000	45	10	80	.....	.....	.....	50,514,657	25,906,463	1892
18,000	50	50	10	.....	.....	.....	48,431,066	28,950,326	1893
40,000	60	8	130	2,369	.....	.....	49,344,516	35,822,095	1894
44,430	50	10	37	3,455	.....	.....	52,892,276	57,032,296	1895
113,571	1,450	43	170	2,878	.....	.....	60,960,361	58,518,709	1896
81,098	65,975	19	625	3,650	.....	.....	60,475,516	40,874,072	1897
71,980	546,070	10	.....	5,475	.....	.....	55,364,233	44,193,359	1898
69,700	669,013	132	.....	5,560	.....	.....	57,070,850	64,603,904	1899
74,714	836,039	[a] 1,602	6,472	5,450	.....	.....	63,620,529	75,989,313	1900
179,151	4,393,658	[a] 2,335	10,000	5,400	.....	.....	69,389,194	66,417,325	1901
331,749	18,083,658	[a] 757	37,100	6,253	548,617	.....	88,766,916	71,178,910	1902
932,214	17,955,572	[a] 3,000	138,911	8,960	917,771	.....	100,461,337	94,694,060	1903
4,250,779	22,241,413	[a] 2,572	1,366,748	11,542	2,958,958	.....	117,080,960	101,175,455	1904
[b] 12,013,496	28,136,189	[a] 3,100	(c)	8,454	8,910,416	.....	134,717,580	84,157,399	1905
[b] 21,718,648	12,567,897	[a] 3,500	(c)	[d] 7,000	9,077,528	.....	126,493,936	92,444,735	1906
2,409,521	12,322,696	[a] 4,000	43,524,128	[e] 9,339	5,000,221	.....	166,095,335	120,106,749	1907
1,801,781	11,206,464	[a] 15,246	45,796,765	[e] 17,775	5,788,874	.....	178,527,355	129,079,184	1908
1,263,764	9,534,467	[a] 5,750	47,859,218	[e] 20,056	3,059,531	.....	183,170,874	128,328,487	1909
1,128,668	8,899,266	[a] 3,615	52,028,718	[e] 115,430	6,841,396	.....	209,557,248	127,899,668	1910
1,278,819	9,526,474	[a] 7,995	56,069,637	[e] 186,695	10,720,420	.....	220,449,391	134,044,752	1911
1,502,796	11,735,057	[h]	51,427,071	1,572,306	9,263,439	.....	222,935,044	164,213,247	1912
2,375,029	15,009,478	[i] 10,843	63,579,384	2,406,522	12,496,828	.....	248,446,230	237,121,388	1913
3,108,585	20,068,184	[f] 7,792	73,631,724	3,560,375	14,309,435	.....	265,762,535	214,126,218	1914
2,823,487	24,942,701	[f] 14,265	97,915,243	4,245,525	18,191,539	.....	281,104,104	179,462,890	1915
8,738,077	27,644,605	[f] 7,705	107,071,715	6,234,137	15,248,138	44,917	300,767,159	330,899,868	1916
66,463,155	256,386,687	94,682	640,465,916	18,444,606	123,335,110	44,917	3,917,328,402	3,302,288,094	

[f] No production in Tennessee recorded.
[g] Includes small production of Alaska.
[h] No production in Missouri; Michigan included in Ohio.
[i] Includes production of Alaska, Michigan, and New Mexico.
[j] Includes production of Alaska and Michigan.

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Petroleum marketed in the United States and average price per barrel in 1915 and 1916.

State.	1915			State.	1916		
	Quantity (barrels).	Value.	Average price per barrel.		Quantity (barrels).	Value.	Average price per barrel.
California	86,591,535	$36,558,439	$0.422	California	90,951,936	$53,702,733	$0.590
Colorado	208,475	183,485	.880	Colorado	197,235	217,139	1.100
Illinois	19,041,695	18,555,850	.980	Illinois	17,714,235	29,237,168	1.650
Indiana	875,758	813,395	.929	Indiana	769,036	1,207,565	1.570
Kansas	2,823,487	1,702,891	.603	Kansas	8,738,077	10,339,958	1.183
Kentucky	437,274	418,357	.957	Kentucky[a]	1,203,246	2,189,312	1.820
Louisiana	18,191,539	10,804,653	.594	Louisiana	15,248,138	14,669,774	.962
New York	887,778	1,390,325	1.566	Montana	44,017	44,019	.980
Ohio	7,825,326	10,061,493	1.286	New York	874,087	2,190,195	2.506
Oklahoma	97,915,243	56,706,133	.579	Ohio	7,744,511	16,154,940	2.086
Pennsylvania	7,838,705	12,431,353	1.586	Oklahoma	107,071,715	128,463,805	1.200
Texas	24,942,701	13,026,925	.522	Pennsylvania	7,592,394	19,149,855	2.522
West Virginia	9,264,798	14,468,278	1.561	Tennessee	(b)	(b)	
Wyoming	4,245,525	2,217,018	.522	Texas	27,644,605	25,760,335	.932
Other States[c]	14,265	24,295	1.703	West Virginia	8,731,184	21,914,060	2.510
				Wyoming	6,234,137	5,644,060	.905
				Other States[c]	7,705	14,410	1.870
	281,104,104	179,462,890	.638		300,767,158	330,899,868	1.100

[a] Includes Tennessee. [b] Included in Kentucky. [c] Alaska, Michigan, and Missouri.

Increase or decrease in quantity of petroleum marketed in 1916 compared with 1915.

State.	Marketed production (barrels).		Increase.		Decrease.	
	1915	1916	Barrels.	Per cent.	Barrels.	Per cent.
California	86,591,535	90,951,936	4,360,401	5.04		
Colorado	208,475	197,235			11,240	5.39
Illinois	19,041,695	17,714,235			1,327,460	6.97
Indiana	875,758	769,036			106,722	12.19
Kansas	2,823,487	8,738,077	5,914,590	209.48		
Kentucky	437,274	[a] 1,203,246	765,972	175.17		
Louisiana	18,191,539	15,248,138			2,943,401	16.18
Montana		44,017	44,017			
New York	887,778	874,087			13,691	1.54
Ohio	7,825,326	7,744,511			80,815	1.03
Oklahoma	97,915,243	107,071,715	9,156,472	9.35		
Pennsylvania	7,838,705	7,592,394			246,311	3.14
Tennessee		(b)				
Texas	24,942,701	27,644,605	2,701,904	10.83		
West Virginia	9,264,798	8,731,184			533,614	5.76
Wyoming	4,245,525	6,234,137	1,988,612	46.84		
Other States[c]	14,265	7,705			6,560	45.99
	281,104,104	300,767,158	19,663,054	6.99		

[a] Includes Tennessee. [b] Included in Kentucky. [c] Alaska, Michigan, and Missouri.

RANK OF OIL-PRODUCING STATES.

QUANTITY.

With regard to the five States that furnished 88 per cent of the petroleum marketed in this country in 1915 and 86 per cent of that marketed in 1916, there were no changes of relative position in 1916. Among the States of less importance as producers of petroleum the most significant change was the advance of Kansas from tenth place in 1915 to sixth in 1916, which place it won from West Virginia by the narrow margin of 6,893 barrels in a total in excess of 8,730,000 barrels. Farther down the line Ohio superseded Pennsylvania, and Kentucky advanced from thirteenth to eleventh place over New York

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and Indiana. Montana, appearing for the first time, preempted fifteenth place, ahead of Alaska, Missouri, Michigan, and Tennessee, which ranked in the order given.

Rank of petroleum-producing States based on quantity of oil marketed, 1915 and 1916.

State.	1915			State.	1916		
	Rank.	Quantity (barrels).	Percentage.		Rank.	Quantity (barrels).	Percentage.
Oklahoma	1	97,915,943	34.83	Oklahoma	1	107,071,715	35.60
California	2	86,591,335	30.81	California	2	90,951,936	30.24
Texas	3	24,942,701	8.87	Texas	3	27,644,605	9.19
Illinois	4	19,041,695	6.77	Illinois	4	17,714,235	5.89
Louisiana	5	18,191,539	6.47	Louisiana	5	15,248,138	5.07
West Virginia	6	9,264,798	3.30	Kansas	6	8,738,077	2.91
Pennsylvania	7	7,838,705	2.79	West Virginia	7	8,731,184	2.90
Ohio	8	7,825,326	2.78	Ohio	8	7,744,511	2.57
Wyoming	9	4,245,525	1.51	Pennsylvania	9	7,592,394	2.52
Kansas	10	2,823,487	1.00	Wyoming	10	6,234,137	2.07
New York	11	887,778	.32	Kentucky	11	[a] 1,203,246	.40
Indiana	12	875,758	.31	New York	12	874,087	.29
Kentucky	13	437,274	.16	Indiana	13	769,036	.26
Colorado	14	208,475	.08	Colorado	14	197,235	.07
Alaska	15	14,265		Montana	15	44,917	.02
Missouri	16			Alaska	16	7,705	
Michigan	17			Missouri	17		
				Michigan	18		
				Tennessee	19	[b]	
		281,104,104	100.00			300,767,158	100.00

[a] Includes Tennessee. [b] Included in Kentucky.

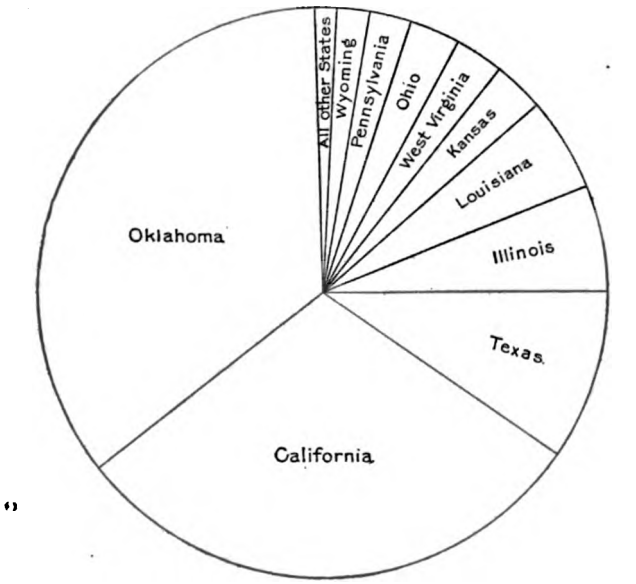

FIGURE 19.—Distribution of petroleum marketed in the United States in 1916.

The accompanying figure shows graphically the relative importance of the several States as contributors to the marketed production of petroleum in the United States in 1916.

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VALUE.

In the order of precedence based on the value of the petroleum marketed in 1916, Texas superseded West Virginia in fourth place, Ohio superseded Louisiana in seventh place, Kansas superseded Wyoming in ninth place, Kentucky superseded Indiana in twelfth place, and Montana preempted fifteenth place, ahead of Alaska, Missouri, Michigan, and Tennessee, which ranked in the order given.

Rank of petroleum-producing States based on value of oil marketed, 1915 and 1916.

State.	1915			State.	1916		
	Rank.	Value.	Percentage.		Rank.	Value.	Percentage.
Oklahoma	1	$56,706,133	31.60	Oklahoma	1	$128,463,805	38.82
California	2	36,558,439	20.37	California	2	53,702,733	16.23
Illinois	3	18,655,850	10.40	Illinois	3	29,237,168	8.84
West Virginia	4	14,468,278	8.06	Texas	4	25,760,335	7.78
Texas	5	13,026,925	7.26	West Virginia	5	21,914,080	6.62
Pennsylvania	6	12,431,353	6.93	Pennsylvania	6	19,149,855	5.79
Louisiana	7	10,804,653	6.02	Ohio	7	16,154,940	4.88
Ohio	8	10,061,493	5.61	Louisiana	8	14,669,774	4.43
Wyoming	9	2,217,018	1.24	Kansas	9	10,339,958	3.13
Kansas	10	1,702,891	.95	Wyoming	10	5,644,080	1.71
New York	11	1,390,325	.77	New York	11	2,190,195	.66
Indiana	12	813,395	.45	Kentucky	12	[a] 2,189,812	.66
Kentucky	13	418,357	.23	Indiana	13	1,207,565	.36
Colorado	14	183,485	.10	Colorado	14	217,139	.07
Alaska	15	24,295	.01	Montana	15	44,019	.02
Missouri	16			Alaska	16		
Michigan	17			Missouri	17	14,410	
				Michigan	18		
				Tennessee	19	[b]	
		179,462,890	100.00			330,809,868	100.00

[a] Includes Tennessee.

[b] Included in Kentucky.

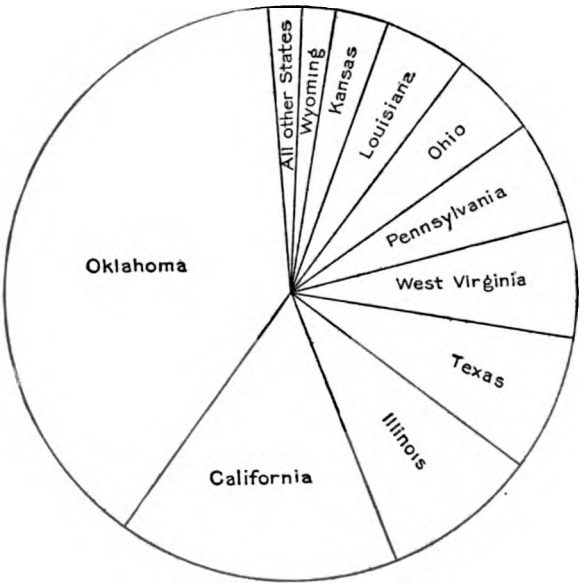

FIGURE 20.—Distribution of value of petroleum marketed in the United States in 1916.

The accompanying figure shows graphically the share of each State in the gross receipts from sales of crude oil at the wells in 1916.

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WORLD'S PRODUCTION OF PETROLEUM.

World's production of crude petroleum in 1916 and since 1857, by countries.

Country.	Production, 1916.			Total production, 1857–1916.		
	Barrels of 42 gallons.	Metric tons.	Percentage of total.	Barrels of 42 gallons.	Metric tons.	Percentage of total.
United States [a]	300,767,158	40,102,288	65.26	[a] 3,917,328,402	[a] 522,310,554	60.46
Russia	[b] 72,801,110	9,933,387	15.50	1,763,583,017	232,917,643	27.22
Mexico	39,817,402	[b] 5,308,987	8.64	163,087,779	21,728,995	2.52
Dutch East Indies [c]	13,174,399	1,820,247	2.86	162,174,312	21,849,705	2.50
Rumania	[b] 10,298,208	1,432,296	2.23	140,310,595	18,910,174	2.16
India	8,491,137	1,132,152	1.84	90,083,522	12,011,136	1.39
Galicia	6,461,706	898,670	1.40	142,494,206	19,817,034	2.20
Japan and Formosa	2,997,178	399,624	.65	33,166,800	4,422,230	.51
Peru	2,550,645	340,086	.55	19,944,868	2,579,315	.30
Trinidad	[d] 1,000,000	139,082	.22	3,819,430	531,214	.06
Germany	995,764	[d] 140,000	.22	14,957,097	2,015,974	.23
Argentina	870,000	116,000	.19	1,903,121	267,693	.03
Egypt	411,000	54,800	.09	1,759,936	234,658	.03
Canada	198,123	26,416	.04	23,907,197	3,187,626	.37
Italy	43,143	[d] 6,000	.01	889,513	125,384	.02
Other countries	[d] 25,000	3,333		397,000	52,933	
	460,901,973	61,853,368	100.00	6,479,206,795	862,962,768	100.00

[a] Marketed production. [b] Estimated in part. [c] Includes British Borneo. [d] Estimated.

Among the countries that contributed to the petroleum output of the world in 1916 there were no changes in rank, as compared with 1915.

The world's production of petroleum was greater in 1916 than in 1915 by 33,161,844 barrels, or 7.8 per cent. Because the output of petroleum in the United States increased in quantity in 1916 only 7 per cent, compared with 1915, this country's proportion of the world's output decreased slightly in 1916, the decrease amounting to 0.47 per cent.

FIGURE 21.—Distribution of world's production of crude petroleum in 1916.

Credit for the largest relative gain in 1916 goes to Mexico, which furnished 8.64 per cent of the world's supply of petroleum in that year, compared with 7.69 per cent in 1915.

The distribution of the world's production of petroleum since 1857 is shown in the table on pages 690–691, and the relative importance of the contribution of each country to the total output in 1916 is shown graphically in the accompanying diagram (fig. 21).

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World's production of crude petroleum since 1857,

Year.	Rumania.	United States.a	Italy.	Canada.	Russia.	Galicia.	Japan and Formosa.	Germany.
1857	1,977	.....	.....	.....	.....	.....	.....	.....
1858	3,560	.....	.....	.....	.....	.....	.....	.....
1859	4,349	2,000	.....	.....	.....	.....	.....	.....
1860	8,542	500,000	36	.....	.....	.....	.....	.....
1861	17,279	2,113,609	29	.....	.....	.....	.....	.....
1862	23,198	3,056,690	29	11,775	.....	.....	.....	.....
1863	27,943	2,611,309	58	82,814	40,816	.....	.....	.....
1864	33,013	2,116,109	72	90,000	64,586	.....	.....	.....
1865	39,017	2,497,700	2,265	110,000	66,542	.....	.....	.....
1866	42,534	3,597,700	992	175,000	83,052	.....	.....	.....
1867	50,838	3,347,300	791	190,000	119,917	.....	.....	.....
1868	55,369	3,646,117	367	200,000	88,327	.....	.....	.....
1869	56,533	4,215,000	144	220,000	202,308	.....	.....	.....
1870	83,765	5,260,745	86	250,000	204,618	.....	.....	.....
1871	90,030	5,205,234	273	269,397	165,129	.....	.....	.....
1872	91,251	6,293,194	331	308,100	184,301	.....	.....	.....
1873	104,066	9,893,786	467	365,052	474,379	.....	.....	.....
1874	103,177	10,926,945	604	168,807	583,751	149,837	.....	.....
1875	108,569	8,787,514	813	220,000	697,364	158,522	4,566	.....
1876	111,314	9,132,669	2,891	312,000	1,320,528	164,157	7,708	.....
1877	108,569	13,350,363	2,934	312,000	1,800,720	169,792	9,560	.....
1878	109,300	15,396,868	4,329	312,000	2,400,960	175,420	17,884	.....
1879	110,007	19,914,146	2,891	575,000	2,761,104	214,800	23,457	.....
1880	114,821	26,286,123	2,035	350,000	3,001,200	229,120	25,497	9,310
1881	121,511	27,661,238	1,237	275,000	3,601,441	286,400	16,751	29,219
1882	136,610	30,349,897	1,316	275,000	4,537,815	330,076	15,549	58,025
1883	139,486	23,449,633	1,618	250,000	6,002,401	365,160	20,473	26,708
1884	210,667	24,218,438	2,855	250,000	10,804,577	408,120	27,923	46,161
1885	198,411	21,858,785	1,941	250,000	13,924,596	465,400	29,237	41,360
1886	168,606	28,064,841	1,575	584,061	18,006,407	305,884	37,916	73,864
1887	181,907	28,283,483	1,496	525,655	18,367,781	343,832	28,645	74,284
1888	218,576	27,612,025	1,251	695,203	23,048,787	466,537	37,436	84,782
1889	297,666	35,163,513	1,273	704,690	24,609,407	515,268	52,811	68,217
1890	383,227	45,823,572	2,998	795,030	28,691,218	659,012	51,420	108,296
1891	488,201	54,292,655	8,305	755,298	34,573,181	630,730	52,917	108,929
1892	503,175	50,514,657	18,321	779,753	35,774,504	646,220	68,901	101,404
1893	535,655	48,431,066	19,089	798,406	40,456,519	692,669	106,384	99,390
1894	507,255	49,344,516	20,552	829,104	36,375,428	949,146	171,744	122,564
1895	575,200	52,892,276	25,843	726,138	46,140,174	1,452,999	141,310	121,277
1896	543,348	60,960,361	18,149	726,822	47,220,633	2,443,080	197,062	145,061
1897	570,886	60,475,516	13,892	709,857	54,399,568	2,226,368	218,559	165,745
1898	776,238	55,364,233	14,489	758,391	61,609,357	2,376,108	265,389	183,427
1899	1,425,777	57,070,850	16,121	808,570	65,954,968	2,313,047	536,079	192,232
1900	1,628,535	63,620,529	12,102	913,498	75,779,417	2,346,505	866,814	358,297
1901	1,678,320	69,389,194	16,150	756,679	85,168,556	3,251,544	1,110,790	313,630
1902	2,059,935	88,766,916	18,933	530,624	80,540,044	4,142,159	1,193,033	353,674
1903	2,763,117	100,461,337	17,876	496,637	75,591,256	5,234,475	1,209,371	445,818
1904	3,599,026	117,080,980	25,476	552,575	78,536,655	5,947,383	1,419,473	637,431
1905	4,420,987	134,717,580	44,027	634,095	54,960,270	5,765,317	1,472,804	560,963
1906	6,378,184	126,493,936	53,577	569,753	58,897,311	5,467,967	1,710,768	578,610
1907	8,118,207	166,095,335	59,875	788,572	61,850,734	8,455,841	2,001,838	756,631
1908	8,252,157	178,527,355	50,966	527,987	62,186,447	12,612,295	2,070,145	1,009,278
1909	9,327,278	183,170,874	42,388	420,755	65,970,350	14,932,799	1,889,563	1,018,837
1910	9,723,806	209,557,248	50,830	315,895	70,336,574	12,673,688	1,930,661	1,032,522
1911	11,107,450	220,449,391	74,709	291,096	66,183,691	10,519,270	1,658,903	1,017,045
1912	12,976,232	222,935,044	53,778	243,336	68,019,208	8,535,174	1,671,405	1,031,050
1913	13,554,768	248,446,230	47,198	228,080	62,834,366	7,818,130	1,942,009	b 995,764
1914	12,826,579	265,762,535	39,849	214,805	67,020,522	b 5,033,350	2,738,378	b 995,764
1915	12,029,913	281,104,104	43,898	215,464	68,548,062	4,158,899	3,118,464	b 995,764
1916	c 10,298,208	300,767,158	b 43,143	198,123	c 72,801,110	6,461,706	2,997,178	b 995,764
	140,310,595	3,917,328,402	889,513	28,907,197	1,763,583,017	142,494,206	33,166,800	14,957,097

a Marketed production. b Estimated.

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by years and countries, in barrels of 42 gallons.

India.	Dutch East Indies.	Peru.	Mexico.	Argentina.	Trinidad.	Egypt.	Other countries.	Total.	Year
.....	.....	.....	.....	.....	.....	.....	.....	1,977	1857
.....	.....	.....	.....	.....	.....	.....	.....	3,560	1858
.....	.....	.....	.....	.....	.....	.....	.....	6,349	1859
.....	.....	.....	.....	.....	.....	.....	.....	508,578	1860
.....	.....	.....	.....	.....	.....	.....	.....	2,130,917	1861
.....	.....	.....	.....	.....	.....	.....	.....	3,091,902	1862
.....	.....	.....	.....	.....	.....	.....	.....	2,762,940	1863
.....	.....	.....	.....	.....	.....	.....	.....	2,303,780	1864
.....	.....	.....	.....	.....	.....	.....	.....	2,715,524	1865
.....	.....	.....	.....	.....	.....	.....	.....	3,890,278	1866
.....	.....	.....	.....	.....	.....	.....	.....	3,708,846	1867
.....	.....	.....	.....	.....	.....	.....	.....	3,990,180	1868
.....	.....	.....	.....	.....	.....	.....	.....	4,695,985	1869
.....	.....	.....	.....	.....	.....	.....	.....	5,799,214	1870
.....	.....	.....	.....	.....	.....	.....	.....	5,780,063	1871
.....	.....	.....	.....	.....	.....	.....	.....	6,877,267	1872
.....	.....	.....	.....	.....	.....	.....	.....	10,837,720	1873
.....	.....	.....	.....	.....	.....	.....	.....	11,923,121	1874
.....	.....	.....	.....	.....	.....	.....	.....	9,977,348	1875
.....	.....	.....	.....	.....	.....	.....	.....	11,051,267	1876
.....	.....	.....	.....	.....	.....	.....	.....	15,753,938	1877
.....	.....	.....	.....	.....	.....	.....	.....	18,416,761	1878
.....	.....	.....	.....	.....	.....	.....	.....	23,601,405	1879
.....	.....	.....	.....	.....	.....	.....	.....	30,017,606	1880
.....	.....	.....	.....	.....	.....	.....	.....	31,992,797	1881
.....	.....	.....	.....	.....	.....	.....	.....	35,704,288	1882
.....	.....	.....	.....	.....	.....	.....	.....	30,255,479	1883
.....	.....	.....	.....	.....	.....	.....	.....	35,968,741	1884
.....	.....	.....	.....	.....	.....	.....	.....	36,764,730	1885
.....	.....	.....	.....	.....	.....	.....	.....	47,243,154	1886
.....	.....	.....	.....	.....	.....	.....	.....	47,807,983	1887
.....	.....	.....	.....	.....	.....	.....	.....	52,164,597	1888
94,250	.....	.....	.....	.....	.....	.....	.....	61,507,095	1889
118,055	.....	.....	.....	.....	.....	.....	.....	76,632,338	1890
190,131	.....	.....	.....	.....	.....	.....	.....	91,100,347	1891
242,284	.....	.....	.....	.....	.....	.....	.....	88,739,219	1892
298,969	600,000	.....	.....	.....	.....	.....	.....	92,038,127	1893
327,218	688,170	.....	.....	.....	.....	.....	.....	89,335,697	1894
371,536	1,215,757	.....	.....	.....	.....	.....	.....	103,662,510	1895
429,979	1,427,132	47,536	.....	.....	.....	.....	.....	114,159,183	1896
545,704	2,551,649	70,831	.....	.....	.....	.....	.....	121,948,575	1897
542,110	2,964,035	70,905	.....	.....	.....	.....	.....	124,924,532	1898
940,971	1,795,961	89,166	.....	.....	.....	.....	.....	131,143,742	1899
1,078,264	2,253,356	274,800	.....	.....	.....	.....	.....	149,132,116	1900
1,430,716	4,013,710	274,800	.....	.....	.....	.....	b 20,000	167,424,089	1901
1,617,363	2,430,465	286,725	.....	.....	.....	.....	b 26,000	181,965,876	1902
2,510,259	5,770,056	278,092	.....	.....	.....	.....	b 36,000	194,804,294	1903
3,385,468	6,508,485	345,834	220,653	.....	.....	.....	b 40,000	218,299,419	1904
4,137,098	7,849,896	447,880	320,379	.....	.....	.....	b 30,000	215,361,296	1905
4,015,803	8,180,657	536,294	1,097,264	.....	.....	.....	b 30,000	214,010,124	1906
4,344,162	9,982,597	756,226	1,717,690	101	.....	.....	b 30,000	264,958,109	1907
5,047,038	10,283,357	1,011,180	3,481,610	11,472	169	.....	b 30,000	285,101,456	1908
6,676,517	11,041,862	1,316,118	2,488,742	18,431	57,143	.....	b 20,000	298,391,647	1909
6,137,990	11,080,620	1,330,105	3,332,807	20,753	142,857	.....	b 20,000	327,636,356	1910
6,451,203	12,172,949	1,368,274	14,051,643	13,119	285,307	9,150	b 20,000	345,673,200	1911
7,116,672	10,845,624	1,751,143	16,558,215	47,007	436,805	205,905	b 20,000	352,446,596	1912
7,930,149	11,172,294	2,133,261	25,902,439	130,618	503,616	94,635	b 20,000	383,753,547	1913
7,409,792	c 11,334,492	1,917,802	21,188,427	275,500	643,533	777,038	b 20,000	398,686,366	1914
8,202,671	c 12,386,900	2,487,251	32,910,508	516,120	b 750,000	262,208	b 10,000	427,740,129	1915
8,491,137	c 13,174,399	2,550,645	39,817,402	870,000	b 1,000,000	411,000	b 25,000	460,901,973	1916
90,083,522	162,174,312	19,344,868	163,087,779	1,903,121	3,819,430	1,759,936	397,000	6,479,206,795	

c Includes British Borneo. b Estimated in part.

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CLASSIFICATION BY FIELDS.

For convenience of discussion the oil pools of the United States are grouped in certain major areas or fields based originally on geographic position alone. As these fields have been extended areally, the geographic boundaries have become in many cases less distinct, and the separation has come to be based more and more on fundamental differences in the type of oil produced and its adaptability to refining needs. Thus the oils of the Appalachian field are in the main of paraffin base, free from asphalt and objectionable sulphur, and they yield by ordinary refining methods high percentages of gasoline and illuminating oils—the products in greatest demand. Contrasted with them is the petroleum of the Lima-Indiana field, which contains some asphalt, though consisting chiefly of paraffin hydrocarbons, and is contaminated with sulphur compounds, which necessitate special treatment for their elimination.

Illinois oils contain varying proportions of both asphalt and paraffin and differ considerably as to specific gravity and distillation products. Sulphur is generally present but rarely in such form as to necessitate special treatment for its removal.

Mid-Continent oils vary in composition within wide limits, ranging from asphaltic oils, poor in gasoline and illuminants, to oils in which the asphalt content is negligible and the paraffin content relatively high and which yield correspondingly high percentages of the lighter products on distillation. Sulphur is present in varying quantities in the lower grade oils, in certain of which—Healdton grade, for example—it exists in the form requiring special treatment for its elimination.

Oils from the Gulf field are characterized by relatively high percentages of asphalt and low percentages of the lighter gravity distillation products. Considerable sulphur is present, much of which, however, is in the form of sulphureted hydrogen and is easily removed by steam before refining or utilizing the oil as fuel.

Oils from Wyoming and Colorado are in the main of paraffin base, suitable for refining by ordinary methods. Heavy asphaltic oils of fuel grade are also obtained in certain of the Wyoming fields. The California oils are generally characterized by much asphalt and little or no paraffin and by varying proportions of sulphur. The chief products are fuel oils, lamp oils, lubricants, and oil asphalt, though low percentages of naphthas may be derived from certain of the lighter oils, notably those of the Santa Maria, Sespe, and Santa Paula fields, in the southern part of the State.

The following table shows the annual distribution by fields of the petroleum marketed in the United States since 1859 and the total quantity contributed by each field since the beginning of the petroleum industry in this country:

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MARKETED PRODUCTION.

Petroleum marketed in the United States, 1859–1916, by fields, in barrels of 42 gallons.

Year.	Appalachian.	California.	Lima-Indiana.	Rocky Mountain.	Illinois.	Mid-Continent.	Gulf.	Other.	United States.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
1859	2,000								2,000
1860	500,000								500,000
1861	2,113,609								2,113,609
1862	3,056,690								3,056,690
1863	2,611,309								2,611,309
1864	2,116,109								2,116,109
1865	2,497,700								2,497,700
1866	3,597,700								3,597,700
1867	3,347,300								3,347,300
1868	3,646,117								3,646,117
1869	4,215,000								4,215,000
1870	5,260,745								5,260,745
1871	5,205,234								5,205,234
1872	6,293,194								6,293,194
1873	9,893,786								9,893,786
1874	10,926,945								10,926,945
1875	8,787,514								8,787,514
1876	9,120,669	12,000							9,132,669
1877	13,337,363	13,000							13,350,363
1878	15,381,641	15,227							15,396,868
1879	19,894,288	19,858							19,914,146
1880	26,245,571	40,552							26,286,123
1881	27,561,376	99,862							27,661,238
1882	30,221,261	128,636							30,349,897
1883	23,306,276	142,857							23,449,633
1884	23,956,438	262,000							24,218,438
1885	21,533,785	325,000							21,858,785
1886	26,549,827	377,145	1,137,869						28,064,841
1887	22,878,241	678,572	4,650,375	76,295					28,283,483
1888	16,941,397	690,333	9,682,683	297,612					27,612,025
1889	22,355,225	303,220	12,186,564	316,476	1,460	500	48	20	35,163,513
1890	30,066,560	307,360	15,078,378	368,842	900	1,200	54	278	45,823,572

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Petroleum marketed in the United States, 1859–1916, by fields, in barrels of 42 gallons—Continued.

Year.	Appalachian.	California.	Lima-Indiana.	Rocky Mountain.	Illinois.	Mid-Continent.	Gulf.	Other.	United States.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
1891	35,848,777	323,600	17,452,612	665,482	675	1,430	54	25	54,292,655
1892	33,432,377	385,049	15,867,575	824,000	521	5,080	45	10	50,514,657
1893	31,365,890	470,179	15,982,097	594,390	400	18,010	50	50	48,431,066
1894	30,783,424	705,969	17,296,510	518,115	300	40,130	60	8	49,344,516
1895	30,960,639	1,208,482	20,236,741	441,687	200	44,467	50	10	52,892,276
1896	33,971,902	1,252,777	25,255,870	364,328	250	115,141	50	43	60,960,361
1897	35,230,271	1,908,411	22,805,033	388,584	500	147,648	50	19	60,475,516
1898	31,717,425	2,257,207	20,321,323	449,858	360	616,600	1,450	10	55,364,233
1899	33,068,356	2,642,095	20,225,356	395,838	360	738,183	530	132	57,070,850
1900	36,295,433	4,334,484	21,758,750	322,535	200	917,225	.....	1,602	63,630,529
1901	33,618,171	8,786,330	21,933,379	465,920	250	989,606	3,598,113	2,335	69,389,194
1902	32,018,787	13,984,268	23,358,626	403,154	200	986,720	18,014,464	757	88,766,916
1903	31,558,248	24,382,472	24,080,264	492,885	.....	1,573,085	18,371,383	3,000	100,461,337
1904	31,408,567	29,649,434	24,689,184	513,305	.....	6,186,629	24,631,269	2,572	117,080,960
1905	29,366,960	33,427,473	22,294,171	384,692	181,084	12,533,777	36,526,323	3,100	134,717,580
1906	27,741,472	33,098,598	17,554,661	334,582	4,397,050	22,839,911	20,524,162	3,500	126,493,936
1907	25,342,137	39,748,375	13,121,094	341,190	24,281,973	46,896,267	16,360,299	4,000	166,095,335
1908	24,945,517	44,854,737	10,032,305	397,428	33,686,238	48,823,747	15,772,137	15,246	178,527,355
1909	26,535,844	55,471,601	8,211,443	330,917	30,898,339	50,833,740	10,883,240	5,750	183,170,874
1910	26,892,579	73,010,560	7,253,861	355,224	33,143,362	59,217,582	9,680,465	3,615	209,557,248
1911	23,749,832	81,134,391	6,231,164	413,621	31,317,038	66,595,477	10,999,873	7,995	220,449,391
1912	26,338,516	87,272,593	4,925,906	1,778,358	28,601,308	65,473,323	8,545,040	.....	222,935,044
1913	25,921,785	97,788,525	4,773,138	2,596,321	23,893,899	84,920,225	8,542,494	10,843	248,446,230
1914	24,101,048	99,775,327	5,062,543	3,783,148	21,919,749	97,994,900	13,118,028	7,792	265,762,535
1915	22,860,048	86,591,535	4,260,591	4,454,000	19,041,695	123,294,317	20,578,653	14,265	281,104,104
1916	23,009,455	90,951,936	3,905,008	6,476,289	17,714,235	136,984,439	21,768,096	7,705	300,767,158
	1,171,504,830	918,817,080	441,634,069	29,544,376	269,082,546	828,739,449	257,911,420	94,682	3,917,328,402

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Petroleum marketed in the United States in 1915 and 1916, by fields.

Field.	1915			1916		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
Appalachian	22,860,048	$35,468,973	$1.552	23,009,455	$56,689,178	$2.464
Lima-Indiana	4,269,591	4,114,228	.964	3,905,003	6,117,269	1.567
Illinois	19,041,695	18,655,850	.980	17,714,235	29,237,168	1.650
Mid-Continent	123,294,317	72,431,301	.587	136,934,439	162,816,998	1.189
Gulf	20,578,653	9,809,301	.477	21,768,096	16,416,874	.754
California	86,591,535	36,558,439	.422	90,951,936	53,702,733	.590
Rocky Mountain	4,454,000	2,400,503	.539	6,476,289	5,905,238	.912
Other fields	[a] 14,265	[a] 24,295	1.703	[a] 7,705	[a] 14,410	1.870
	281,104,104	179,462,890	.638	300,767,158	330,899,868	1.100

[a] Includes Alaska, Michigan, and Missouri.

Petroleum marketed in the United States in 1915 and 1916, by fields, with percentage of increase or decrease.

Field.	Marketed production (barrels).		Increase.		Decrease.	
	1915	1916	Barrels.	Per cent.	Barrels.	Per cent.
Appalachian	22,860,048	23,009,455	149,407	0.65		
Lima-Indiana	4,269,591	3,905,003			364,588	8.54
Illinois	19,041,695	17,714,235			1,327,460	6.97
Mid-Continent	123,294,317	136,934,439	13,640,122	11.06		
Gulf	20,578,653	21,768,096	1,189,443	5.78		
California	86,591,535	90,951,936	4,360,401	5.04		
Rocky Mountain	4,454,000	6,476,289	2,022,289	45.40		
Other fields	[a] 14,265	[a] 7,705			6,560	45.99
	281,104,104	300,767,158	19,663,054	6.99		

[a] Includes Alaska, Michigan, and Missouri.

Petroleum marketed in the United States, 1912–1916, by fields, in barrels.

Field.	1912	1913	1914	1915	1916
Appalachian	26,338,516	25,921,785	24,101,048	22,860,048	23,009,455
Lima-Indiana	[a] 4,925,906	4,773,138	5,062,543	4,269,591	3,905,003
Illinois	28,601,308	23,893,899	21,919,749	19,041,695	17,714,235
Mid-Continent	65,473,323	84,920,225	97,994,900	123,294,317	136,934,439
Gulf	8,545,040	8,542,494	13,118,028	20,578,653	21,768,096
California	[b] 87,272,593	97,788,525	99,775,327	86,591,535	90,951,936
Rocky Mountain	1,778,358	2,595,321	3,783,148	4,454,000	6,476,289
Other fields		[c] 10,843	[c] 7,792	[d] 14,265	[c] 7,705
	222,935,044	248,446,230	265,762,535	281,104,104	300,767,158

[a] Includes Michigan.
[b] Includes Alaska.
[c] Includes Alaska, Michigan, Missouri, and New Mexico.
[d] Includes Alaska, Michigan, and Missouri.

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Percentages of petroleum marketed in the several fields, 1912–1916.

Field.	1912	1913	1914	1915	1916
Appalachian	11.81	10.430	9.07	8.13	7.650
Lima-Indiana	2.21	1.930	1.90	1.52	1.298
Illinois	12.83	9.620	8.25	6.77	5.890
Mid-Continent	29.37	34.180	36.87	43.86	45.528
Gulf	3.83	3.440	4.94	7.32	7.238
California	39.15	39.356	37.54	30.81	30.240
Rocky Mountain	.80	1.040	1.43	1.585	2.153
Other fields	.....	.004		.005	.003
	100.00	100.000	100.00	100.000	100.000

DELIVERIES.

Petroleum delivered to trade in 1915 and 1916, by fields, in barrels.

Field.	1915			1916		
	Refining.	Fuel.	Total.	Refining.	Fuel.	Total.
Appalachian	[a] 22,843,247	.....	22,843,247	[b] 24,901,407	.....	24,901,407
Lima-Indiana	2,995,922	3,636	2,999,558	4,730,455	[c] 4,831	4,735,286
Illinois	21,246,359	[d] 31,065	21,277,424	22,428,763	[e] 13,514	22,442,277
Kansas-Oklahoma	[f] 90,520,272	1,288,178	91,808,450	113,431,845	768,632	114,200,477
Louisiana	13,357,805	1,884,119	15,241,924	22,481,184	1,703,433	24,184,617
Texas	15,540,527	4,744,685	20,285,212	11,152,968	3,861,675	15,014,643
California	57,037,769	40,626,668	97,664,437	65,354,107	30,787,562	96,141,669
Colorado and Wyoming	3,932,087	281,286	4,199,108	6,143,104	20,893	6,156,292
Other fields			14,265			7,705
	227,473,988	48,859,637	276,333,625	270,623,833	37,160,540	307,784,373

[a] Includes 61,805 barrels of lubricating oil.
[b] Includes 45,427 barrels of lubricating oil.
[c] Includes 157 barrels used for street sprinkling.
[d] Includes 725 barrels used for hog dip and street sprinkling.
[e] Includes 652 barrels used for hog dip and street sprinkling.
[f] Includes 467,458 barrels shipped by rail that can not be classified.

STOCKS AND STORAGE.

The reserve of petroleum aboveground in the United States is the working stock from which the refining industry draws its supply, and fluctuations in this reserve normally have considerable influence on the market price of crude oil. When conditions of production are such that this reserve is steadily increasing, a decline in market prices for crude petroleum may be expected. When, however, requisitions become necessary to keep the refineries operating to capacity, prices of oil in the field tend to advance and stimulate additional drilling.

This reserve is distributed among several classes of holders, the bulk, however, being in the custody of the large pipe-line companies engaged in interstate transportation of petroleum. Additional quantities are held in tanks and reservoirs in or adjacent to productive fields and at the various refineries throughout the country.

Statistics of the quantity of crude oil held by refiners of petroleum in tanks adjacent to their plants are not available. This reserve, however, is not large in the aggregate and fluctuates but little from year to year.

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PIPE-LINE STOCKS.

The statistics tabulated below show the quantities of crude oil of various grades in the custody of the pipe-line companies of the United States at the close of business on December 31, and include also the stocks held at storage centers by important purchasing and marketing agencies other than pipe-line companies.

Stocks of all grades of petroleum at the end of 1915 and 1916, in barrels.

Grade of oil.	Held by eastern pipe lines and refineries.[a]		In pipe-line storage outside of eastern field.		Total.		Increase.	Decrease.
	1915	1916	1915	1916	1915	1916		
Pennsylvania[b]	5,488,553	3,423,612	.....	.....	5,488,553	3,423,612	.....	2,064,941
Lima	2,918,648	2,088,365	.....	.....	2,918,648	2,088,365	.....	830,283
Illinois[c]	1,550,703	1,268,155	9,777,311	5,331,817	11,328,014	6,599,972	.....	4,728,042
Kentucky	252,943	425,932	.....	.....	252,943	425,932	172,989	.....
Kansas, Oklahoma	2,710,207	4,300,809	64,245,992	64,264,705	66,956,199	68,565,514	1,609,315	.....
Texas	.....	.....	9,601,544	13,062,532	9,601,544	13,061,532	3,459,988	.....
Louisiana	.....	.....	4,761,079	4,994,574	4,761,079	4,994,574	233,495	.....
California	.....	.....	44,588,084	39,398,351	44,588,084	39,398,351	.....	5,189,733
Rocky Mountain	.....	.....	425,184	745,181	358,891	745,181	319,997	.....
	12,921,054	11,506,873	133,399,194	127,797,160	146,253,955	139,303,033	.....	7,017,215

[a] These pipe lines connect with the delivering lines of the Illinois, Kansas, and Oklahoma fields and receive and transfer large quantities of these western oils to the Atlantic seaboard in addition to the oil from wells directly tributary to their own systems.
[b] Includes natural lubricating oil from Pennsylvania and West Virginia.
[c] Includes some Indiana oil of Illinois grade.

FIELD STORAGE.

The following table shows the quantity of unmarketed petroleum reported by the producers as held in field tanks and reservoirs at the close of business on December 31, 1916:

Petroleum in field storage at end of 1916.

	Barrels.		Barrels.
Appalachian field	344,590	Gulf field	132,746
Lima-Indiana field	76,884	Rocky Mountain field	217,829
Illinois field	404,974	California field	6,760,857
Mid-Continent field	43,034,000		
			50,971,880

SUMMARY OF WELLS DRILLED.

The following tables, compiled from trade journal sources with the exception of the statistics for Alaska, California, Colorado, Michigan, Missouri, Montana, Utah, Wyoming, and miscellaneous, which are taken from reports furnished by the oil producers themselves, show in condensed form the results of activity in drilling for oil in the United States in the last two years.

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Wells drilled in the United States in 1915 and 1916.

Field.	Wells completed.				Initial daily production (barrels).	
	Oil.	Gas.	Dry.	Total.	Total.	Average per well.
1915.						
Appalachian:						
Pennsylvania and New York	1,409	213	284	1,906	9,320	6.6
Southeastern and central Ohio	677	761	472	1,910	8,373	12.4
West Virginia	763	280	246	1,289	13,501	17.7
Kentucky	56	.....	36	92	728	13.0
Tennessee	4	1	7	12	250	62.5
	2,909	1,255	1,045	5,209	32,172	11.1
Lima, Ohio	224	10	27	261	4,496	20.1
Indiana	98	8	86	192	2,564	26.2
	322	18	113	453	7,060	21.9
Illinois	539	19	199	757	14,165	26.3
Mid-Continent:						
Kansas	610	331	147	1,088	11,319	18.6
Oklahoma	3,397	342	885	4,624	1,036,170	305.0
Central and northern Texas	307	23	198	528	52,663	171.5
Northern Louisiana	349	26	89	464	198,116	567.7
	4,663	722	1,319	6,704	1,298,268	278.4
Gulf:						
Coastal and southern Texas	306	5	230	541	292,541	956.0
Coastal Louisiana	73	2	26	101	45,185	619.0
	379	7	256	642	337,726	891.1
Arkansas	.....	1	1	2	.....	.....
California	272	.....	20	292	.....	.....
Colorado	3	.....	6	9	.....	.....
Michigan	2	.....	.....	2	.....	.....
Missouri	2	.....	2	4	.....	.....
Wyoming and Utah	63	.....	11	74	.....	.....
Miscellaneous	.....	.....	9	9	.....	.....
	9,154	2,022	2,981	14,157	.....	.....
1916.						
Appalachian:						
Pennsylvania and New York	2,500	255	296	3,051	10,774	4.3
Southeastern and central Ohio	927	402	525	1,854	10,838	11.7
West Virginia	1,055	442	296	1,793	24,234	23.0
Kentucky	878	17	179	1,074	27,310	31.1
Tennessee	2	.....	7	9	45	22.5
	5,362	1,116	1,303	7,781	73,201	13.7
Lima, Ohio	616	11	72	699	9,325	15.1
Indiana	160	8	98	266	3,554	22.2
	776	19	170	965	12,879	16.6
Illinois	1,107	36	318	1,461	24,789	22.4
Mid-Continent:						
Kansas	3,142	112	370	3,624	248,846	79.2
Oklahoma	6,086	377	1,120	7,583	521,895	85.8
Central and northern Texas	500	38	145	683	49,728	99.5
Northern Louisiana	324	55	141	520	54,871	169.4
	10,052	582	1,776	12,410	875,340	87.1
Gulf:						
Coastal and southern Texas	647	28	355	1,030	388,422	600.3
Coastal Louisiana	104	1	41	146	111,310	1,070.3
	751	29	396	1,176	499,732	665.4
Arkansas	.....	21	11	32	.....	.....
California	613	.....	32	645	.....	.....
Colorado	3	.....	6	9	.....	.....
Missouri	.....	.....	3	3	.....	.....
Montana	6	.....	1	7	.....	.....
Wyoming and Utah	106	.....	21	127	.....	.....
Miscellaneous	1	.....	2	3	.....	.....
	18,777	1,803	4,039	24,619	.....	.....

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FUEL OIL.

GENERAL STATEMENT.

The year 1916 was one of continued expansion in the domestic market for petroleum fuel by reason of the stimulus to industry and transportation in this country resulting from the increasing demands abroad for all kinds of raw materials and finished products employed directly or indirectly in the conduct of the great war.

The maintenance of a high rate of production of petroleum from which a relatively large percentage of fuel oil is obtained in the coastal pools of Texas and Louisiana, the increased production of fuel grades of oil in Mexico, and the increase in the number of tankers available for the bulk transport of oil from Mexico to the United States, have created in the territory adjacent to the Atlantic and Gulf seaboards a confidence in the abundance of the supply of petroleum suitable for fuel purposes that has encouraged its adoption wherever practicable.

West of the Rocky Mountains, however, the diminishing output of low-gravity oil from the productive fields of California resulted in 1916 in increased prices that tended to curtail its consumption and to circumscribe its applications. In the States of the Middle West, which depend for their fuel oils on the residual products of the refining industry, conditions in the trade were none too encouraging. Despite an increase in the number of refineries operating and a record output of crude oil, the tendency of the refiners to devise and adopt new methods of operation calculated to reduce if not to eliminate the output of heavy residuals served as a deterring influence on the expansion of the fuel-oil trade in this region.

The future market for petroleum fuel in the United States is along the Atlantic and Gulf seaboards, where it can be delivered cheaply in bulk from Mexican sources. The expense of transporting oil inland by rail is too great to permit this form of fuel to become a successful competitor with the great sources of coal for the fuel markets of the interior.

That the principal oil companies of the United States have abundant confidence in the future of the fuel-oil trade in general is shown by a recent estimate of the tonnage of oil tankers in Atlantic waters. This estimate credits seven oil companies with a fleet aggregating 540,000 gross tons in actual operation at the end of 1916 and with additional tankers aggregating 294,000 gross tons under construction, for delivery in 1917.

PRICES.

Prices of fuel oil ranged appreciably higher in 1916 than in 1915, their course throughout the country reflecting rather closely that of the prices for crude petroleum at the wells and, in the States of the Pacific coast, the growing stringency in supply.

The following tabulation of monthly prices per barrel for semi-refined fuel oil at typical marketing centers in the Southwest and on the Pacific coast is compiled from the Oil Trade Journal (New York).

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Monthly prices per barrel of semirefined fuel oil in 1916.

Month.	Houston, Tex.	Tulsa, Okla.	San Francisco, Cal.	Seattle, Wash.
January	$1.05	$1.00-$1.05	$0.80	$1.00
February	1.05	1.05- 1.10	.80	1.00
March	1.10	1.10- 1.20	.80	1.00
April	$1.00- 1.05	.85- .95	.80	1.00
May	.85- .90	.60- .80	.80	1.00
June	.80- .85	.60- .80	.80	1.00
July	.75- .80	.55- .75	$0.80- 1.00	$1.00- 1.20
August	.75- .80	.55- .75	1.00	1.20
September	.75- .80	.55- .75	1.00- 1.05	1.20- 1.25
October	.80- .90	.60- .80	1.05	1.25
November	.95- 1.00	1.00- 1.25	1.05- 1.10	1.25
December	.95- 1.00	1.00- 1.25	1.10- 1.15	1.25- 1.30

CONSUMPTION.

Complete statistics of the consumption of fuel oil in the United States are not available. Data compiled from reports of pipe-line companies show that 37,160,540 barrels of domestic crude petroleum were delivered for fuel in 1916. In addition more than 18,000,000 barrels of oil, much of which was used for fuel, was imported from Mexico. Indeterminate quantities of refinery residuals of domestic oil found the same use. In the oil fields of the United States some 3,340,250 barrels of crude oil, of which the transporting companies never obtained a record, were consumed directly in drilling and pumping operations. In California alone 2,778,660 barrels of oil were used for this purpose.

RAILROADS.

The principal consumers of petroleum fuel in the United States are the trunk railroads of the West and Southwest, whose lines traverse sections of the country devoid of other suitable fuels. The increased traffic on these lines, resulting from the mobilization of United States troops on the Mexican frontier and from the increased movement of freight and passengers in a period of country-wide prosperity, is reflected in an increase of 15 per cent in the quantity of fuel oil consumed in locomotives in 1916, compared with 1915. This increase is believed to record an expansion in the United States of the market for low-grade petroleum from Mexico rather than any appreciable gain in the use of low-gravity domestic oils, which are finding an ever widening use in the manufacture of lubricants.

Fuel oil consumed by the railroads of the United States, 1907–1916.

Year.	Fuel oil consumed.	Length of line operated by the use of fuel oil.a	Total mileage made by oil-burning engines.	Average number of miles per barrel of oil consumed.
	Barrels.	*Miles.*	*Miles.*	*Miles.*
1907	18,849,803	13,573	74,079,726	3.93
1908	16,870,382	15,474	64,279,509	3.81
1909	19,905,335	17,676	72,918,118	3.66
1910	23,317,346	22,709	89,107,883	3.74
1911	29,748,845	30,089	109,080,976	3.69
1912	33,605,598	28,451	121,393,228	3.61
1913	33,004,315	29,145	118,672,162	3.60
1914	31,093,266	29,595	118,737,469	3.82
1915	36,648,466	30,776	124,255,525	3.39
1916	42,126,417	31,980	140,434,566	3.33

a Some of these lines also used coal.

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The following railroad companies used fuel oil on their lines in 1916:

Arizona:
Atchison, Topeka & Santa Fe Railway System.
Southern Pacific Co.
Arkansas:
Kansas City Southern Railway Co.
California:
Atchison, Topeka & Santa Fe Railway System.
Los Angeles & Salt Lake Railroad Co.
Northwestern Pacific Railroad Co.
San Diego & Arizona Railway Co.
San Diego & Southeastern Railway Co.
Southern Pacific Co.
Tonopah & Tidewater Railroad Co.
Western Pacific Railroad Co.
Florida:
Florida East Coast Railway Co.
Georgia:
Central of Georgia Railway Co. (on Tybee district).
Idaho:
Chicago, Milwaukee & St. Paul Railway Co.
Great Northern Railway Co.
Oregon Short Line Railroad Co.
Washington, Idaho & Montana Railway Co.
Kansas:
Atchison, Topeka & Santa Fe Railway System.
Kansas City Southern Railway Co.
Louisiana:
Atchison, Topeka & Santa Fe Railway System.
Houston & Shreveport Railroad Co.
Iberia & Vermilion Railroad.
Kansas City Southern Railway Co.
Louisiana Railway & Navigation Co.
Louisiana Western Railroad Co.
Morgan's Louisiana & Texas Railroad & Steamship Co.
New Orleans, Texas & Mexico Railroad.
Texas & Pacific Railway.
Missouri:
Kansas City Southern Railway Co.
Montana:
Chicago, Burlington & Quincy Railroad Co.
Chicago, Milwaukee & St. Paul Railway Co.
Great Northern Railway Co.
Oregon Short Line Railroad Co.
Nebraska:
Chicago & Northwestern Railway Co.
Nevada:
Atchison, Topeka & Santa Fe Railway System.
Bullfrog Goldfield Railroad Co.
Las Vegas & Tonopah Railroad Co.
Los Angeles & Salt Lake Railroad Co.
Southern Pacific Co.
Tonopah & Goldfield Railroad Co.
Tonopah and Tidewater Railroad Co.
Western Pacific Railroad Co.
New Mexico:
Atchison, Topeka & Santa Fe Railway System.
El Paso Southwestern System.
Southern Pacific Co.
New York:
Delaware & Hudson Co. (in the Adirondacks).
Long Island Railroad Co.
New York Central Railroad Co. (in the Adirondacks, including Old Forge and the Fulton Chain).
Oklahoma:
Atchison, Topeka & Santa Fe Railway System
Kansas City Southern Railway Co.

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Oregon:
Great Northern Railway Co.
Northern Pacific Railway Co.
Oregon Trunk Railway Co.
Oregon-Washington Railroad & Navigation Co.
Southern Pacific Co.
Spokane, Portland & Seattle Railway Co.
South Dakota:
Chicago, Burlington & Quincy Railroad Co.
Chicago & Northwestern Railway Co.
Texas:
Atchison, Topeka & Santa Fe Railway System.
Beaumont, Sour Lake & Western Railway.
Fort Worth & Denver City Railway Co.
Galveston, Harrisburg & San Antonio Railway Co.
Galveston, Houston & Henderson Railroad Co.
Houston, East & West Texas Railway Co.
Houston & Texas Central Railroad Co.
International & Great Northern Railway Co.
Orange & Northwestern Railroad Co.
St. Louis, Brownsville & Mexico Railway.
San Antonio & Aransas Pass Railway Co.
Texarkana & Fort Smith Railway Co.
Texas & New Orleans Railroad Co.
Texas & Pacific Railway.
Trinity & Brazos Valley Railway Co.
Utah:
Los Angeles & Salt Lake Railroad Co.
Southern Pacific Co.
Washington:
Bellingham & Northern Railway Co.
Chicago, Milwaukee & St. Paul Railway Co.
Great Northern Railway Co.
Northern Pacific Railway Co.
Oregon Trunk Railway Co.
Oregon-Washington Railroad & Navigation Co.
Spokane, Portland & Seattle Railway Co.
Washington, Idaho & Montana Railway Co.
Wyoming:
Chicago, Burlington & Quincy Railroad Co.
Chicago & Northwestern Railway Co.

UNITED STATES NAVY.

The consumption of petroleum fuel by the United States Navy in the fiscal year ending June 30, 1916, was 842,432 barrels, compared with 521,382 barrels in the fiscal year ending June 30, 1915.

On account of the great increase in the naval building program approved by Congress in 1916, it has been estimated that the fuel requirements of the Navy in the fiscal year 1916–17 will include about 1,475,000 barrels of oil, and if conditions necessitate the maintenance of the Navy on a war basis about 5,000,000 barrels will be required in the fiscal year 1917–18.

Appropriations were authorized by Congress in 1916 for the immediate construction of 4 oil-burning battle cruisers and 4 oil-burning dreadnaughts. Under the three-year program adopted 10 additional dreadnaughts and 6 additional battle cruisers, all oil burners, are to be completed prior to 1922. The new dreadnaughts provided for will burn 27,325 pounds of oil an hour at a speed of 21 knots, and 4,460 pounds an hour at the ordinary cruising speed of 10 knots. The new battle cruisers will burn 163,750 pounds of oil an hour at a speed of 31 knots and 5,440 pounds an hour at a speed of 10 knots.

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It is estimated that the electric drive installed on the dreadnaughts *California* and *Tennessee* and proposed for the new units planned will reduce somewhat the consumption of fuel oil, compared with that in the direct steam-driven units.

The specifications under which fuel oil is supplied for naval use in the fiscal year 1917–18 are as follows:

(*a*) Fuel oil shall be a hydrocarbon oil free from grit, acid, and fibrous or other foreign matter likely to clog or injure the burners or valves. If required by the Navy Department, it shall be strained by being drawn through filters of wire gauze having 16 meshes to the inch. The clearance through the strainer shall be at least twice the area of the suction pipe and strainers shall be in duplicate.

(*b*) The unit of quantity to be the barrel of 42 gallons of 231 cubic inches at a standard temperature of 60° F. For every decrease or increase of temperature of 10° F. (or proportion thereof) from the standard, 0.4 of 1 per cent (or prorated percentage) shall be added or deducted from the measured or gaged quantity for correction.

(*c*) The flash point shall not be lower than 150° F. as a minimum (Abel or Pensky-Marten's closed cup) or 175° F. (Tagliabue open cup). In case of oils having a viscosity greater than 8 Engler at 150° F., the flash point (closed cup) shall not be below the temperature at which the oil has a viscosity of 8 Engler.

(*d*) Viscosity shall not be greater than 40 Engler [1] at 70° F.

(*e*) No residuum of any destructive distillation, or so-called "cracking process," to be mixed or included in fuel oil furnished the Navy under this contract.

(*f*) Water and sediment not over 1 per cent. If in excess of 1 per cent, the excess to be subtracted from the volume; or the oil may be rejected.

(*g*) Sulphur not over 0.75 per cent.

(*h*) Fuel oil meeting the requirements of the Navy, whether derived from American crudes or from Mexican crudes, or from a mixture of the two, will be considered. The quality and kind of oil shall be fully described in the bid, together with the information of the original source from which the oil is to be obtained and the treatment to which it is to be subjected. The contractor will be required to deliver the oil specified in the proposal upon which contract is awarded.

In order to assure the Navy a future supply of liquid fuel, the President of the United States approved on December 6, 1916, orders creating naval oil-shale reserves Nos. 1 and 2, involving, respectively, 45,440 acres in Garfield County, Colo., and 86,584 acres in Uinta County, Utah. The lands thus set apart for the use of the Navy contain deposits of shale which are estimated to be competent to yield when mined and distilled a minimum of 500,000,000 barrels of oil suitable for marine fuel.

FIELD USE.

The use of crude petroleum as a fuel for the drilling and pumping of wells is restricted for the most part to fields that produce oils of relatively low grade or to areas where other fuels are not available at prices that would effect an economy in their adoption. Wherever natural gas is available it is used in preference to petroleum fuel for field operations, and in California the advent of cheap hydroelectric power has resulted in a notable decrease in the field consumption of crude oil.

The statistics presented in the following table are compiled from the reports of producing companies and show that approximately 1 per cent of the total quantity of petroleum produced in the United States in 1916 was consumed in drilling or pumping operations in the field.

[1] If the Engler viscosimeter is not available, the Saybolt standard universal viscosimeter may be used. Equivalent viscosities: 8 Engler = 300 seconds Saybolt; 40 Engler = 1,500 seconds Saybolt.

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Crude petroleum used as field fuel in 1916.

	Barrels.
Illinois field	7,645
Mid-Continent field	71,825
Gulf field	470,362
Rocky Mountain field	11,760
California field	2,778,659
	3,340,251

PETROLEUM OPERATORS' STATISTICS.

The statistics presented in this section are those obtained directly from the oil producers themselves. The object of this investigation, in addition to securing a check on the determination of marketed production, as reported by the pipe-line and other oil-transporting companies, is to secure a record of petroleum utilized in field operations and to obtain details available in no other way concerning field storage, drilling activity, and acreage held for development.

It will be noted that the statistics of wells completed as given in this section differ with respect to many States and counties from those given elsewhere in this chapter. The statistics presented here are those obtained from voluntary reports by the petroleum operators themselves and relate merely to the number of wells involved. Those published elsewhere, with the exception of the field reports for Colorado, Wyoming, Montana, Utah, California, Michigan, Missouri, Alaska, and miscellaneous, which are obtained from the statements of the operators, are compiled from various trade journals, principally the Oil City Derrick and the Oil and Gas Journal, and are published because they are consistent since the beginning of the oil industry in the United States and because they furnish in addition to the number of wells completed an approximation of the output of each oil well the first day of its productive life. No attempt is made to procure data on this subject from the oil producers.

Petroleum marketed, well record, and acreage held by operators in the United States in 1916.

[From statistics furnished by producers.]

State.	Wells.					Acreage.		
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
		Oil.	Dry.					
Alaska	8	.....	.....	1	7	148	9,000	9,148
Arkansas	.....	.....	2	.....	.....	1,280	29,240	30,520
California	7,314	613	32	143	7,784	154,085	163,486	317,571
Colorado	93	3	6	11	85	15,557	21,438	36,995
Illinois	15,180	991	183	333	15,838	2,575	160,880	163,455
Indiana	2,900	128	45	503	2,525	4,464	62,094	66,558
Kansas	3,673	2,354	333	189	5,838	25,185	715,818	741,003
Kentucky	1,059	831	204	79	1,861	53,841	256,662	310,503
Louisiana	1,538	437	157	247	1,728	23,621	394,253	417,874
Michigan	28	.....	.....	.....	28	15	3,040	3,055
Missouri	14	.....	3	.....	14	.....	25,600	25,600
Montana	.....	6	1	.....	6	280	4,650	4,930
New Mexico	1	.....	1	.....	1	800	4,102	4,902
New York	11,028	264	18	92	11,200	34,632	65,404	100,036
Ohio	30,811	1,421	301	1,388	30,844	59,119	759,615	818,734
Oklahoma	29,131	3,452	507	887	31,696	48,362	1,394,734	1,443,096
Pennsylvania	56,443	1,616	249	1,612	58,447	300,762	802,573	1,103,335
Tennessee	4	2	7	4	2	42	62,549	62,591
Texas	4,331	1,261	550	406	5,186	43,462	913,780	957,242
Utah	6	.....	3	1	5	11,700	3,500	15,200
Washington	.....	1	1	1	.....	50	7,500	7,550
West Virginia	15,337	936	154	385	15,888	372,314	2,106,882	2,479,196
Wyoming	320	106	18	10	416	17,019	59,011	76,030
	181,219	14,472	2,775	6,292	189,399	1,169,313	8,025,811	9,195,124
Total, 1915	179,377	7,871	1,975	6,029	181,219	987,676	9,014,069	10,001,745

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Wells drilled and acreage held in 1916 in oil-producing States.

New York.

County.	Wells.					Acreage.		
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
		Oil.	Dry.					
Allegany	7,666	188	6	60	7,794	19,764	36,280	56,044
Cattaraugus	3,139	76	11	32	3,183	13,368	28,145	41,513
Steuben	223	.....	1	.....	223	1,500	979	2,479
	11,028	264	18	92	11,200	34,632	65,404	100,036
Total, 1915	11,087	101	7	160	11,028	36,338	68,206	104,544

Pennsylvania.

Allegheny	1,756	65	28	71	1,750	12,303	68,513	80,816
Armstrong	184	7	.....	3	188	2,021	1,968	3,989
Beaver	665	36	21	7	694	1,498	16,790	18,288
Butler	5,620	164	56	443	5,341	25,101	74,015	99,116
Clarion	1,965	57	17	42	1,980	10,063	43,852	59,915
Crawford	704	22	.....	9	717	1,040	3,633	4,673
Elk	1,148	12	1	.....	1,160	27,577	61,425	89,002
Forest	1,609	37	18	20	1,626	40,072	30,009	70,081
Greene	510	16	13	7	519	756	111,460	112,216
Jefferson	150	2	4	.....	152	629	36,798	37,427
Lawrence	1,002	53	7	33	1,022	1,337	12,342	13,679
McKean	15,604	329	20	139	15,794	73,729	117,452	191,181
Mercer	326	13	.....	7	332	478	6,522	7,000
Potter	92	.....	2	8	84	1,286	722	2,008
Tioga	24	.....	.....	.....	24	.....	367	367
Venango	17,895	574	39	734	17,735	57,494	79,748	137,242
Warren	7,339	180	14	45	7,474	36,236	55,086	91,322
Washington	1,850	49	9	44	1,855	3,142	81,871	85,013
	58,443	1,616	249	1,612	58,447	300,762	802,573	1,103,335
Total, 1915	58,254	1,368	182	1,179	58,443	282,585	806,019	1,088,604

West Virginia.

Braxton	15	2	5	1	16	1	4,219	4,220
Boone	.....	.....	1	.....	.....	947	82,118	83,065
Brooke	282	18	3	17	283	820	4,902	5,722
Cabell	25	.....	.....	7	18	2,015	2,816	4,831
Calhoun	205	5	1	2	208	1	9,401	9,402
Clay	63	15	.....	3	75	.....	10,656	10,656
Doddridge	587	48	13	12	623	4,106	84,169	88,275
Fayette	.....	.....	1	.....	.....	.....	1,707	1,707
Gilmer	101	6	1	1	106	.....	68,144	68,144
Hancock	347	12	.....	12	347	2,165	4,331	6,496
Harrison	1,338	72	19	60	1,350	3,858	79,146	83,004
Jackson	1	1	.....	.....	2	.....	600	600
Kanawha	715	172	9	8	879	4,977	357,914	362,891
Lewis	276	4	.....	5	275	40,000	111,593	151,593
Lincoln	769	121	3	15	875	280,014	345,868	625,882
Logan	.....	1	.....	.....	1	.....	1,945	1,945
Marion	712	44	4	14	742	69	60,468	60,537
Marshall	129	7	4	3	133	104	15,439	15,543
Mason	3	.....	.....	3	.....	.....	1,078	1,078
Mercer	.....	.....	1	.....	.....	.....	.....	.....
Monongalia	719	15	1	20	714	1,320	39,632	40,952
Nicholas	.....	.....	2	.....	.....	.....	.....	.....
Ohio	4	.....	.....	.....	4	.....	5	5
Pleasants	1,707	57	12	19	1,745	990	25,088	26,078
Putnam	1	.....	.....	.....	1	.....	380	380
Ritchie	1,940	94	14	58	1,976	3,038	89,153	92,191
Roane	1,175	64	8	17	1,222	10,923	511,570	522,493
Tyler	1,542	30	10	19	1,553	1,612	67,025	68,637
Wayne	7	2	1	2	7	8,363	.....	8,363
Wetzel	1,144	29	10	38	1,135	2,387	95,714	98,101
Wirt	520	44	13	40	524	2,745	19,268	22,013
Wood	950	73	18	9	1,014	1,859	12,533	14,392
	15,337	936	154	385	15,888	372,314	2,106,882	2,479,196
Total, 1915	15,069	711	111	443	15,337	30,373	2,422,987	2,453,360

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Wells drilled and acreage held in 1916 in oil-producing States—Continued.

Kentucky.

County.	Wells.					Acreage.		
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
		Oil.	Dry.					
Allen	31	72	53	1	102	2,510	60,783	63,293
Barren	7	4			11	31	2,000	2,031
Bath	89	2	6		91		3,805	3,805
Edmonson	1			1				
Estill	8	683	87	10	681	22,280	73,120	95,400
Floyd	20	1	1		21		2,675	2,675
Jackson			2					
Knott	2				2		568	568
Lawrence	43	23	1	1	64	2,833	11,119	13,952
Lewis	6				6	12,000		12,000
Lee		1	3		1			
Logan	6			6				
McCreary	6	1	1	2	5	7,800	2,000	9,800
Madison		3	1		3		11,500	11,500
Martin		1			1			
Metcalf		1	1		1			
Morgan	27	2	6	2	27	1,200	2,425	3,625
Ohio	4			1	3		1,000	1,000
Powell		19	6		19	75	19,000	19,075
Rockcastle			1				2,500	2,500
Rowan	35				35		2,500	2,500
Warren		1			1			
Wayne	628	54	30	41	641	5,112	49,967	55,079
Whitley			1					
Wolfe	146	14	4	14	146		11,700	11,700
Total, 1915	1,059	881	204	79	1,861	53,841	256,662	310,503
	1,032	76	51	49	1,059	22,024	112,521	134,545

Ohio.

Allen	1,105	24	1	35	1,094	553	19,256	19,809
Ashland	6	1			7	54	515	569
Athens	153	16		7	162	410	5,023	5,433
Auglaize	486	4	1	125	365	218	10,012	10,230
Belmont	189	5	3	10	184	50	36,321	36,371
Carroll	73	23	31	1	95	180	48,774	48,954
Columbiana	384	11	16	9	386	826	17,814	18,640
Coshocton	62	6		1	67	6	26,229	26,235
Cuyahoga	3	5	4	3	5	59	280	339
Erie	2				2		600	600
Fairfield	295	9	5	15	289	160	10,809	10,969
Guernsey	9				9		760	760
Hancock	3,154	184	4	20	3,318	1,297	32,539	33,836
Hardin	3	4			7	60	2,000	2,060
Harrison	683	56	2	7	732	1,091	10,947	12,038
Hocking	265	95	37	10	350	3,062	50,937	53,999
Holmes	37	2	3		39	1,707	1,883	3,590
Jefferson	521	38	29	35	524	2,135	30,622	32,757
Knox	10	3			13		1,600	1,600
Lawrence	16				16		395	395
Licking	73	23	4		96	200	36,629	36,829
Logan	3		2	1	2		30	30
Lorain	8	1			9			
Lucas	495	7		51	451	561	6,211	6,772
Mahoning	133	14	3		147	75	3,220	3,295
Medina	2				2		240	240
Meigs	7	3			10		1,595	1,595
Mercer	588	56	1	34	610	1,478	10,821	12,299
Monroe	2,553	48	21	66	2,535	6,353	39,210	45,563
Morgan	1,131	205	13	12	1,324	3,142	11,794	14,936
Muskingum	177	34	5	3	208	699	28,478	29,177
Noble	569	25	10	7	587	2,214	10,531	12,745
Ottawa	421	11		109	323	782	5,936	6,718
Perry	652	76	10	41	687	2,667	48,263	50,930
Sandusky	4,052	68	9	92	4,028	6,595	38,687	45,282
Seneca	637	45	2	14	668	1,634	6,281	7,915
Shelby	16	1			17		460	460
Trumbull	20			3	17	100	10,615	10,715
Van Wert	575	28		44	559	919	8,651	9,570
Vinton	10	32	19		42	60	69,868	69,928
Washington	4,012	114	46	93	4,033	8,167	49,548	57,715
Wayne	65				65		2,241	2,241
Wood	7,156	144	20	540	6,760	11,605	62,990	74,595
Total, 1915	30,811	1,421	301	1,388	30,844	59,119	759,615	818,734
	31,891	768	276	1,848	30,811	66,790	738,114	804,904

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Wells drilled and acreage held in 1916 in oil-producing States—Continued.

Indiana.

County.	Wells.					Acreage.		
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
		Oil.	Dry.					
Adams	370	6	.....	64	312	630	8,153	8,783
Blackford	64	3	.....	28	39	.....	1,074	1,074
Daviess	3	.....	.....	.....	3	.....	140	140
Delaware	114	6	.....	84	36	100	2,376	2,476
Gibson	116	.....	1	10	106	.....	7,348	7,348
Grant	212	.....	.....	46	166	1	4,066	4,067
Green	6	1	1	.....	7	.....	100	100
Huntington	184	.....	.....	112	72	.....	1,410	1,410
Jay	749	4	1	67	686	3,300	10,138	13,438
Pike	156	19	6	11	164	93	7,386	7,479
Porter	.....	.....	1	.....	.....	.....	.....	.....
Randolph	42	2	.....	4	40	240	2,469	2,709
Sullivan	503	73	32	49	527	.....	8,721	8,721
Vigo	22	14	2	1	35	.....	2,356	2,356
Warrick	.....	.....	1	.....	.....	.....	40	40
Wells	359	.....	.....	27	332	100	6,317	6,417
Total, 1915	2,900	128	45	503	2,525	4,464	62,094	66,558
	3,418	93	53	611	2,900	6,611	106,981	113,592

Illinois.

Clark	2,258	165	7	102	2,321	214	18,095	18,309
Clinton	150	5	11	.....	155	.....	2,667	2,667
Coles	82	3	.....	25	60	.....	490	490
Crawford	7,609	384	119	148	7,845	775	81,514	82,289
Cumberland	758	30	5	4	784	228	4,917	5,145
Edgar	11	.....	.....	.....	11	560	90	650
Hancock	1	.....	.....	.....	1	.....	10	10
Henderson	.....	.....	3	.....	.....	.....	5,000	5,000
Jackson	.....	.....	1	.....	.....	.....	1,000	1,000
Jasper	9	.....	.....	.....	9	.....	160	160
Lawrence	3,933	232	19	35	4,130	515	39,655	40,170
McDonough	237	140	6	10	367	123	1,750	1,873
Macoupin	5	.....	.....	2	3	.....	690	690
Madison	2	.....	.....	.....	2	.....	350	350
Marion	102	14	4	2	114	.....	1,969	1,969
Morgan	3	.....	.....	.....	3	160	400	560
Tazewell	.....	2	4	.....	2	.....	1,000	1,000
Wabash	20	16	4	5	31	.....	1,123	1,123
Total, 1915	15,180	991	183	333	15,838	2,575	160,880	163,455
	14,800	517	126	137	15,180	3,134	251,083	254,217

Kansas.

Allen	387	216	13	38	565	1,355	17,492	18,847
Bourbon	.....	.....	1	.....	.....	.....	800	800
Butler	20	797	117	1	816	400	372,245	372,645
Chase	.....	.....	1	.....	.....	.....	.....	.....
Chautauqua	1,315	284	49	23	1,576	10,460	68,235	78,695
Clark	.....	.....	2	.....	.....	.....	.....	.....
Coffey	23	4	.....	1	26	.....	882	882
Cowley	2	4	11	1	5	.....	44,008	44,008
Elk	7	10	4	.....	17	.....	1,160	1,160
Franklin	138	136	12	11	263	1,550	10,352	11,902
Greenwood	.....	1	6	.....	1	.....	10,000	10,000
Labette	10	2	2	7	5	2,987	7,500	10,487
Linn	.....	.....	1	.....	.....	.....	.....	.....
Lyon	.....	.....	2	.....	.....	.....	.....	.....
Miami	145	143	25	25	263	750	7,204	7,954
Montgomery	1,048	514	38	24	1,538	5,343	123,990	129,333
Morris	.....	.....	1	.....	.....	.....	.....	.....
Neosho	414	171	27	55	530	1,300	22,575	23,875
Sedgwick	.....	.....	2	.....	.....	.....	5,074	5,074
Sumner	.....	.....	1	.....	.....	.....	.....	.....
Wilson	162	67	10	3	226	1,040	15,344	16,384
Woodson	2	5	8	.....	7	.....	8,957	8,957
Total, 1915	3,673	2,354	333	189	5,838	25,185	715,818	741,003
	3,460	409	158	256	3,673	36,388	401,192	437,580

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Wells drilled and acreage held in 1916 in oil-producing States—Continued.

Oklahoma.

County.	Wells.					Acreage.		
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
		Oil.	Dry.					
Alfalfa			1					
Atoka			2				60	60
Bryan			3				1,300	1,300
Carter	616	675	22	9	1,282	1,074	42,408	43,482
Coal			6				525	525
Comanche	13	5	5	1	17	20	11,730	11,750
Craig	13	2	1		15		4,907	4,907
Creek	4,180	975	54	81	5,074	7,323	233,597	240,920
Garfield		2			2		320	320
Garvin	8			8				
Greer			1				1,050	1,050
Haskell			1				80	80
Hughes	1		1	1			3,000	3,000
Jefferson	4	6	2	1	9		2,142	2,142
Kay	137	21	18	26	132	655	98,300	98,955
Kiowa	6		1	2	4	160	5,600	5,760
Love	1		1	1				
McClain			1				1,375	1,375
McIntosh	10		1		10		160	160
Marshall	3		4		3	20	120	140
Muskogee	425	260	59	12	673	1,598	49,505	51,103
Nowata	6,963	235	27	277	6,941	6,451	84,450	90,901
Okfuskee	18	6	6		24		56,608	56,608
Oklahoma	1		1	1				
Okmulgee	1,425	283	100	73	1,635	12,555	116,211	128,766
Osage	2,632	144	16	34	2,742	944	243,549	244,493
Pawnee	623	44	18	6	661	2,267	30,385	32,652
Payne	10	11	3	1	20		37,412	37,412
Pittsburg		1			1		4,600	4,600
Pontotoc	6	15	5	2	19	5	15,554	15,559
Pottawatomie			2					
Rogers	2,267	107	13	52	2,322	1,569	26,847	28,416
Seminole			1					
Sequoyah			1					
Stephens	2	1	3		3		9,457	9,457
Tillman			1				80	80
Tulsa	3,513	268	60	89	3,692	3,647	187,503	191,150
Wagoner	46	98	30	4	140	112	6,045	6,157
Washington	6,188	293	36	206	6,275	9,962	119,854	129,816
	29,131	3,452	507	887	31,696	48,362	1,394,734	1,443,096
Total, 1915	27,803	2,193	339	865	29,131	75,508	1,887,257	1,962,765

Texas.

Aransas			1					
Archer	10	2			12		7,275	7,275
Bastrop			9				19,880	19,880
Bee			1					
Bell			6				3,180	3,180
Bexar	12	25	9	4	33	3	4,186	4,189
Brazoria			1				1,000	1,000
Cameron			1					
Chambers			2				2,040	2,040
Childress			1					
Clay	348	41	45	14	375	4,363	33,516	37,879
Coleman	1	1	2		2	2,200	56,360	58,560
Duval	7	6	6	1	12	1,196	4,535	5,731
Ellis			1					
Fayette			1					
Gaines			1					
Guadalupe			1					
Hardin	1,067	211	54	107	1,171	5,212	7,880	13,092
Harris	446	332	164	146	632	4,446	39,961	44,407
Hidalgo			1					
Houston			3					
Jack	52	9	3		61		26,000	26,000
Jefferson	101	15	12	30	86	35	962	997
Karnes			1					
Kleberg			1					
Lee			3				3,000	3,000
Liberty	4	3	5	2	5	2,018	3,022	5,040

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Wells drilled and acreage held in 1916 in oil-producing States—Continued.

Texas—Continued.

County.	Wells.					Acreage.		
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
		Oil.	Dry.					
Live Oak			1					
McLennon	12		2		12	320	10,000	10,320
McMullen	23				23		4,326	4,326
Marion	39	8	9	16	31	3,143	3,730	6,873
Matagorda	31	8	4	4	35	731	6,913	7,644
Medina			2				2,000	2,000
Milan			6			3,000	5,650	8,650
Montgomery			2				30,000	30,000
Nacogdoches	2	1		2	1		1,200	1,200
Navarro	864	61	15	32	893	1,084	13,270	14,354
Nueces			2			232	1,100	1,332
Orange	1		1		1		31	31
Palo Pinto	44	58	52	3	99	10,000	220,358	230,358
Panola			1				18,083	18,083
Polk			1					
San Patricio			4				1,800	1,800
Shackelford	5	13	10		18	3	30,161	30,164
Tarrant			1			40	2,000	2,040
Travis			1					
Washington	1	3	6	3	1	50	1,650	1,700
Wharton	2		1	2			209	209
Wichita	1,134	419	73	26	1,527	5,126	337,177	342,303
Wilbarger		5	3		5		1,467	1,467
Williamson	125	40	17	14	151	260	9,858	10,118
Wood			1					
Total, 1915	4,331	1,261	550	406	5,186	43,462	913,780	957,242
	3,841	726	483	236	4,331	48,093	802,929	851,022

Louisiana.

Acadia	76	21	2	16	81	795	1,656	2,451
Allen			1					
Avoyelles			1					
Bossier			5			157	22,502	22,659
Caddo	953	184	48	106	1,031	18,653	97,233	115,886
Calcasieu	112	73	31	46	139	994	5,858	6,852
De Soto	140	47	29	30	157	234	124,386	124,620
Grant			1					
Jefferson Davis	10		4	2	8	180	3,763	3,943
Nachitoches			2				10,431	10,431
Red River	234	110	33	41	303	345	107,539	107,884
Sabine	1				1	316	13,175	13,491
St. Martin	12	2		6	8	1,947	7,710	9,657
Total, 1915	1,538	437	157	247	1,728	23,621	394,253	417,874
	1,177	503	130	142	1,538	26,338	616,441	642,779

PIPE-LINE STATISTICS.

Under this heading are included statistics furnished by pipe-line and other transporting agencies, with which are incorporated, wherever appropriate and without differentiation, supplemental data, including statistics of fuel consumed in field operations and statistics of local sales of crude petroleum by producers, concerning which the transportation companies would have no record.

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APPALACHIAN OIL FIELD.

GENERAL STATEMENT.

The Appalachian field embraces all oil pools east of central Ohio and north of central Alabama, including those of New York, Pennsylvania, West Virginia, southeastern Ohio, Kentucky, Tennessee, and northern Alabama.

The formations that yield oil in this field include those of the Devonian and Carboniferous systems. The oil occurs generally along the axes and flanks of anticlines, parallel in general with the strike of the Appalachian Mountains, on minor terraces or other structures associated with them, and rarely in waterless synclines. The reservoir rocks are mainly sandstone or conglomerate layers, the most notable exception being the Big lime (Greenbrier limestone), a calcareous stratum that yields oil in West Virginia.

MARKETED PRODUCTION.

Petroleum marketed in the Appalachian field in 1915 and 1916, in barrels.

Month.	Pennsylvania.	New York.	Southeastern Ohio.	West Virginia.	Kentucky.	Total.
1915.						
January	629,588	74,101	382,236	777,702	34,898	1,898,525
February	615,005	67,755	361,100	754,034	35,707	1,833,601
March	672,343	79,840	398,430	848,926	39,562	2,039,101
April	697,036	79,018	385,427	801,046	40,015	2,002,542
May	638,490	75,114	362,097	767,685	39,323	1,882,709
June	683,410	76,408	377,345	789,545	37,070	1,963,778
July	682,583	79,012	366,426	780,749	35,905	1,944,675
August	655,242	72,531	357,799	761,111	37,531	1,884,214
September	654,036	72,914	353,556	752,751	34,929	1,868,186
October	645,333	72,399	363,534	716,638	33,564	1,831,468
November	623,955	66,218	342,700	720,267	34,702	1,787,842
December	641,684	72,468	380,843	794,344	34,068	1,923,407
	7,838,705	887,778	4,431,493	9,264,798	437,274	22,860,048
1916.						
January	625,720	72,216	355,553	647,805	33,751	1,735,045
February	555,410	61,611	344,767	672,843	40,657	1,675,288
March	625,987	64,909	385,306	751,018	51,323	1,878,543
April	662,241	79,439	371,192	674,056	65,545	1,852,473
May	701,435	80,140	401,866	765,938	86,102	2,035,481
June	658,195	78,586	422,673	737,701	81,409	1,978,564
July	641,148	76,489	389,532	704,071	94,001	1,905,241
August	663,901	76,552	409,467	749,881	134,432	2,034,233
September	609,754	72,946	376,239	706,416	143,093	1,908,448
October	638,244	73,056	388,561	783,475	162,060	2,045,396
November	605,049	68,351	386,229	786,723	157,685	2,004,037
December	605,310	69,792	377,159	751,257	153,188	1,956,706
	7,592,394	874,087	4,608,544	8,731,184	[a] 1,203,246	23,009,455

[a] Includes 677 barrels from Tennessee.

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Petroleum marketed in the Appalachian field since 1859.

Year.	Quantity (barrels).	Percentage of total production.	Increase or decrease.		Value.	Yearly average price per barrel.
			Barrels.	Per cent.		
1859	2,000	100.00			$32,000	$16.000
1860	500,000	100.00	+ 498,000	+24,900.00	4,800,000	9.590
1861	2,113,609	100.00	+1,613,609	+ 322.72	1,035,668	.490
1862	3,056,690	100.00	+ 943,081	+ 44.62	3,209,525	1.050
1863	2,611,309	100.00	− 445,381	− 14.57	8,225,663	3.150
1864	2,116,109	100.00	− 495,200	− 18.96	20,896,576	8.060
1865	2,497,700	100.00	+ 381,591	+ 18.03	16,459,853	6.590
1866	3,597,700	100.00	+1,100,000	+ 44.04	13,455,398	3.740
1867	3,347,300	100.00	− 250,400	− 6.96	8,066,993	2.410
1868	3,646,117	100.00	+ 298,817	+ 8.93	13,217,174	3.625
1869	4,215,000	100.00	+ 568,883	+ 15.60	23,730,450	5.638
1870	5,260,745	100.00	+1,045,745	+ 24.81	20,503,754	3.860
1871	5,205,234	100.00	− 55,511	− 1.06	22,591,180	4.340
1872	6,293,194	100.00	+1,087,960	+ 20.90	21,440,503	3.640
1873	9,893,786	100.00	+3,600,592	+ 57.21	18,100,464	1.830
1874	10,926,945	100.00	+1,033,159	+ 10.44	12,647,527	1.170
1875	8,787,514	100.00	−2,139,431	− 19.58	7,368,133	1.350
1876	9,120,669	99.87	+ 333,155	+ 3.79	22,952,822	2.563
1877	13,337,363	99.90	+4,216,694	+ 46.23	31,756,066	2.420
1878	15,381,641	99.90	+2,044,278	+ 15.33	18,009,346	1.190
1879	19,894,288	99.90	+4,512,647	+ 29.34	17,164,836	.859
1880	26,245,571	99.85	+6,351,283	+ 31.93	24,506,963	.945
1881	27,561,376	99.64	+1,315,805	+ 5.01	25,217,612	.915
1882	30,221,261	99.58	+2,659,885	+ 9.65	23,334,016	.772
1883	23,306,776	99.39	−6,914,485	− 22.88	25,460,252	1.092
1884	23,956,438	98.92	+ 649,662	+ 2.79	19,990,746	.834
1885	21,533,785	98.51	−2,422,653	− 10.11	18,447,493	.856
1886	26,549,827	94.60	+5,016,042	+ 23.29	18,681,910	.704
1887	22,878,241	80.90	−3,671,586	− 13.83	16,279,971	.712
1888	16,941,397	61.36	−5,936,844	− 25.95	14,836,701	.876
1889	22,355,225	63.57	+5,413,828	+ 31.96	24,485,407	.941
1890	30,066,560	65.61	+7,711,335	+ 34.50	30,121,968	.868
1891	35,848,777	66.03	+5,782,217	+ 19.23	24,219,863	.670
1892	33,432,377	66.19	−2,416,400	− 6.74	18,830,773	.556
1893	31,365,890	64.76	−2,066,487	− 6.18	20,327,232	.640
1894	30,783,424	62.38	− 582,466	− 1.86	26,030,125	.839
1895	30,960,639	58.54	+ 177,215	+ .58	42,206,898	1.359
1896	33,971,902	55.73	+3,011,263	+ 9.73	40,208,418	1.179
1897	35,230,271	58.25	+1,258,369	+ 3.70	27,877,213	.786
1898	31,717,425	57.29	−3,512,846	− 9.97	29,096,057	.911
1899	33,068,356	57.94	+1,350,931	+ 4.26	43,041,677	1.294
1900	36,295,433	57.05	+3,227,077	+ 9.76	49,235,298	1.353
1901	33,618,171	48.45	−2,677,262	− 7.38	40,796,327	1.210
1902	32,018,787	36.07	−1,599,384	− 4.76	40,451,593	1.288
1903	31,558,248	31.41	− 460,539	− 1.44	49,905,813	1.590
1904	31,408,567	26.83	− 149,681	− .47	50,598,184	1.628
1905	29,366,960	21.80	−2,041,607	− 6.50	40,279,635	1.304
1906	27,741,472	21.93	−1,625,488	− 5.54	43,633,601	1.598
1907	25,342,137	15.26	−2,399,335	− 8.65	43,766,686	1.745
1908	24,945,517	13.97	− 396,620	− 1.57	43,888,020	1.780
1909	26,535,844	14.49	+1,590,327	+ 6.38	43,237,233	1.646
1910	26,892,579	12.83	+ 356,735	+ 1.33	35,841,749	1.336
1911	23,749,832	10.77	−3,142,747	− 11.37	30,830,354	1.308
1912	26,338,516	11.81	+2,588,684	+ 10.90	42,818,384	1.626
1913	25,921,785	10.43	− 416,731	− 1.58	63,708,981	2.458
1914	24,101,048	9.07	−1,820,737	− 7.02	45,239,201	1.877
1915	22,860,048	8.13	−1,241,000	− 5.15	35,468,973	1.552
1916	23,009,455	7.65	+ 149,407	+ .55	56,689,178	2.464
	1,171,504,830	29.906			1,575,249,936	1.345

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Petroleum marketed, value, and average price per barrel in the Appalachian field, 1907–1916.

Year.	Pennsylvania.			New York.			Southeastern Ohio.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1907....	9,999,306	$17,579,706	$1.758	1,212,300	$2,127,748	$1.755	4,214,391	$7,344,408	$1.742
1908....	9,424,325	16,881,194	1.791	1,160,128	2,071,533	1.786	4,110,121	7,316,617	1.780
1909....	9,299,403	15,424,554	1.658	1,134,897	1,878,217	1.655	4,717,436	7,773,880	1.648
1910....	8,794,662	11,908,914	1.354	1,053,838	1,414,668	1.342	4,822,234	6,469,939	1.342
1911....	8,248,158	10,894,074	1.321	952,515	1,248,950	1.311	4,281,237	5,591,423	1.306
1912....	7,837,948	12,886,752	1.644	874,128	1,401,880	1.604	5,013,110	8,177,189	1.631
1913....	7,917,302	19,690,502	2.487	948,191	2,284,307	2.409	4,964,425	12,229,610	2.463
1914....	8,170,335	15,573,822	1.906	938,974	1,760,868	1.875	4,809,265	8,937,415	1.858
1915....	7,838,705	12,431,353	1.584	887,778	1,390,325	1.566	4,431,493	6,760,660	1.526
1916....	7,592,394	19,149,855	2.522	874,087	2,190,195	2.516	4,608,544	11,245,236	2.440

Year.	West Virginia.			Kentucky-Tennessee.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1907....	9,095,296	$15,852,428	$1.743	820,344	$862,396	$1.051	25,342,137	$43,766,686	$1.729
1908....	9,523,176	16,911,865	1.776	[a] 727,767	706,811	.971	24,945,517	43,888,020	1.759
1909....	10,745,092	17,642,283	1.642	[a] 639,016	518,299	.811	26,535,844	43,237,233	1.629
1910....	11,753,071	15,723,544	1.338	[a] 468,774	324,684	.692	28,892,579	35,841,749	1.332
1911....	9,795,464	12,767,293	1.303	[a] 472,458	328,614	.695	23,749,832	30,830,354	1.298
1912....	12,128,062	19,927,721	1.643	[a] 484,368	424,842	.877	26,338,516	42,818,384	1.625
1913....	11,567,299	28,828,814	2.492	[a] 524,568	675,748	1.288	25,921,785	63,708,981	2.458
1914....	9,680,033	18,468,540	1.908	[a] 502,441	498,556	.992	24,101,048	45,239,201	1.877
1915....	9,264,798	14,468,278	1.561	[a] 437,274	418,357	.957	22,860,048	35,468,973	1.552
1916....	8,731,184	21,914,080	2.510	[b] 1,203,246	[b] 2,189,812	1.820	23,009,455	56,689,178	2.464

[a] No production in Tennessee recorded. [b] Includes 677 barrels, $1,317 from Tennessee.

Petroleum marketed in the Appalachian field, 1912–1916, in barrels.

Month.	1912	1913	1914	1915	1916
January	1,694,048	2,178,053	2,103,509	1,898,525	1,735,045
February	1,834,665	1,982,615	1,773,632	1,833,601	1,675,288
March	2,227,769	2,046,832	2,245,177	2,039,101	1,878,543
April	2,276,208	2,307,646	2,271,018	2,002,542	1,852,473
May	2,462,881	2,251,441	2,131,921	1,882,709	2,035,481
June	2,360,533	2,188,442	2,153,470	1,963,778	1,978,564
July	2,413,806	2,253,474	2,211,697	1,944,675	1,905,241
August	2,442,319	2,130,941	1,216,397	1,884,214	2,034,233
September	2,133,327	2,135,811	1,760,930	1,868,186	1,908,448
October	2,253,291	2,237,913	2,329,973	1,831,468	2,045,396
November	2,033,801	1,972,899	1,895,464	1,787,842	2,004,037
December	2,205,868	2,235,718	2,007,860	1,923,407	1,956,706
	26,338,516	25,921,785	24,101,048	22,860,048	23,009,455

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Average daily output of petroleum in the Appalachian field, 1912–1916, in barrels.

Month.	1912	1913	1914	1915	1916
January	54,647	70,260	67,855	61,243	55,969
February	63,264	70,808	63,344	65,486	57,769
March	71,864	66,027	72,425	65,777	60,590
April	74,259	76,921	75,701	66,751	61,749
May	82,029	72,627	68,772	60,733	65,661
June	76,684	72,948	71,782	65,459	65,952
July	77,865	72,693	71,345	62,731	61,459
August	78,784	68,740	39,239	60,781	65,620
September	71,111	71,194	58,698	62,273	63,615
October	72,687	72,191	75,160	59,080	65,981
November	67,793	75,763	63,182	59,595	66,801
December	71,157	72,120	64,770	62,045	63,120
Average	71,963	71,024	66,030	62,630	62,867

RUNS, STOCKS, AND DELIVERIES.

RUNS.

Pipe-line runs of Appalachian oil in 1915 and 1916, in barrels.

1915.

Month.	National Transit.	Southwest Pennsylvania.	Eureka.	Cumberland.	New York Transit.	Tidewater.
January	216,106	103,123	712,263	34,898	14,840	108,208
February	210,492	107,585	660,994	34,255	14,307	98,243
March	233,653	113,592	772,896	38,204	17,085	115,561
April	247,587	118,377	725,307	38,995	15,774	118,852
May	220,977	111,122	693,722	37,271	16,984	108,380
June	241,036	115,474	714,724	35,459	15,737	115,360
July	243,640	110,722	700,258	32,643	16,544	114,327
August	231,908	107,648	685,436	32,504	14,819	111,416
September	221,887	104,758	673,533	30,930	15,321	107,734
October	216,618	102,547	641,894	29,297	15,885	112,183
November	202,857	103,355	645,151	31,926	13,679	101,154
December	208,379	102,429	712,673	30,701	14,436	111,715
	2,695,140	1,300,732	8,368,851	407,083	185,411	1,323,128

Month.	Producers and Refiners.	Emery.	Buckeye Macksburg.	Franklin.	Other lines.	Total.
January	173,678	27,864	278,611	3,485	225,454	1,898,525
February	167,678	27,332	263,134	2,937	216,644	1,833,601
March	180,889	29,323	290,294	3,353	244,251	2,039,101
April	178,163	30,185	281,413	3,595	244,294	2,002,542
May	167,993	27,976	266,878	2,813	228,593	1,882,709
June	171,502	30,005	279,891	3,196	241,394	1,963,778
July	180,666	29,310	268,175	3,241	245,149	1,944,675
August	169,876	26,933	266,566	1,941	235,167	1,884,214
September	170,452	27,782	263,270	2,177	250,342	1,868,186
October	168,735	26,581	270,254	4,901	242,573	1,831,468
November	159,925	27,039	254,463	3,062	245,231	1,787,842
December	173,632	28,255	282,385	6,639	252,163	1,923,407
	2,063,189	338,585	3,265,334	41,340	2,871,255	22,860,048

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Pipe-line runs of Appalachian oil in 1915 and 1916, in barrels—Continued.

1916.

Month.	National Transit.	Southwest Pennsylvania.	Eureka.	Cumberland.	New York Transit.	Tidewater.
January	208,980	99,350	575,302	30,799	14,641	108,280
February	182,984	96,415	600,121	38,345	12,424	93,986
March	204,846	108,767	674,080	49,242	12,864	101,622
April	243,149	101,112	604,219	63,104	16,516	114,814
May	245,282	113,011	690,804	83,349	16,865	120,116
June	229,861	108,075	665,718	76,469	15,615	114,243
July	221,005	103,184	631,024	85,974	14,987	113,142
August	225,360	113,219	678,532	125,799	15,431	115,630
September	205,496	103,605	627,592	136,659	14,206	110,287
October	217,903	108,621	678,904	155,147	14,522	112,046
November	199,279	108,237	649,728	152,652	13,054	104,610
December	193,021	112,437	661,744	147,213	13,378	105,918
	2,577,166	1,276,033	7,737,768	1,144,752	174,503	1,315,694

Month.	Producers and Refiners.	Emery.	Buckeye Macksburg.	Franklin.	Other lines.	Total.
January	165,903	28,690	258,982	3,684	240,484	1,735,045
February	158,177	24,732	249,017	2,227	216,860	1,675,288
March	177,913	27,599	279,908	2,852	238,855	1,878,543
April	165,656	29,242	271,073	3,203	240,385	1,852,473
May	180,754	30,818	290,708	3,399	260,375	2,035,481
June	172,466	29,261	311,731	3,204	251,921	1,978,564
July	165,182	29,251	285,043	2,930	258,519	1,905,241
August	170,928	29,429	297,725	3,354	258,526	2,034,233
September	160,572	27,115	270,649	2,786	249,481	1,908,448
October	176,091	27,404	283,194	2,815	268,749	2,045,396
November	210,962	26,112	282,050	2,890	254,463	2,004,037
December	171,905	26,800	266,612	2,884	253,794	1,956,706
	2,076,509	336,453	3,346,637	36,228	2,987,712	23,009,455

STOCKS.

Stocks of petroleum held by eastern pipe lines[a] in the Appalachian field at end of each month in 1915 and 1916, in barrels.

1915.

Month.	National Transit.	Southwest Pennsylvania.	Eureka.	Cumberland.	Southern.	Crescent.
January	938,322	733,633	1,691,675	173,340	524,982	105,969
February	953,606	669,059	1,677,590	162,124	505,687	137,307
March	964,244	692,848	1,582,528	143,588	506,286	117,635
April	1,069,871	690,087	1,625,385	149,449	523,058	111,601
May	1,026,914	571,682	1,303,009	130,362	614,063	71,554
June	1,050,772	554,427	1,587,754	108,600	520,545	59,484
July	1,096,922	631,076	1,652,493	112,804	591,815	71,921
August	1,059,720	663,713	1,596,685	120,068	568,418	58,605
September	974,752	528,025	1,759,586	139,088	459,629	65,042
October	978,336	504,534	2,001,451	149,315	463,725	66,431
November	911,649	528,775	1,826,944	158,683	757,544	60,323
December	872,089	607,356	2,074,858	169,259	698,654	92,895

[a] These pipe lines connect with the delivering lines of the Illinois, Kansas, and Oklahoma fields and receive and transfer large quantities of these western oils to the Atlantic seaboard in addition to the oil from wells directly tributary to their own systems.

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Stocks of petroleum held by eastern pipe lines in the Appalachian field at the end of each month in 1915 and 1916, in barrels—Continued.

1915—Continued

Month.	New York Transit.	Tidewater.	Northern.	Producers and Refiners.	Emery.	Buckeye Macksburg.
January	842,900	754,766	584,468	710,779	14,004	705,144
February	828,436	716,208	710,656	746,384	11,855	743,327
March	917,880	706,285	635,381	777,079	9,619	750,380
April	1,084,815	662,415	600,745	802,653	13,129	685,072
May	1,143,824	622,852	630,266	818,940	13,855	680,490
June	955,324	531,757	525,712	827,437	14,061	538,243
July	1,473,660	630,729	620,811	815,010	15,453	536,792
August	1,374,598	630,796	519,367	811,486	26,087	497,289
September	1,333,714	607,775	588,490	815,494	27,000	597,678
October	1,212,387	712,059	501,121	805,818	31,881	520,479
November	981,556	791,162	556,614	701,469	40,659	617,992
December	1,061,910	763,819	575,869	710,324	45,588	614,501

Month.	Buckeye Lima.	Indiana.	Franklin.	Other lines.	Total.
January	1,999,987	1,180,830	67,142	230,197	11,258,138
February	1,964,235	1,361,887	70,097	206,536	11,464,994
March	2,060,798	1,322,233	73,481	290,216	11,552,481
April	2,289,932	1,136,828	77,235	388,329	11,800,604
May	2,270,441	1,144,857	80,173	371,012	11,494,294
June	2,649,171	1,107,097	83,848	429,172	11,543,404
July	2,431,251	1,127,270	85,030	802,848	12,726,885
August	2,053,110	1,154,797	86,557	1,062,721	12,284,017
September	2,161,297	1,172,262	86,245	1,126,848	12,442,925
October	2,272,231	1,185,596	69,394	1,125,024	12,599,782
November	2,293,598	1,159,820	49,179	1,180,624	12,616,591
December	2,235,796	1,015,814	49,459	1,332,913	12,921,054

1916.

Month.	National Transit.	Southwest Pennsylvania.	Eureka.	Cumberland.	Southern.	Crescent.
January	956,546	565,068	1,828,652	189,752	751,880	74,573
February	962,465	584,024	2,004,218	160,453	567,955	61,898
March	962,983	699,281	1,789,970	107,870	809,338	80,177
April	977,477	598,004	1,657,792	117,629	779,746	93,164
May	962,501	649,303	1,686,605	124,404	538,926	104,050
June	1,027,359	586,768	1,518,794	125,274	589,741	120,329
July	878,519	529,850	1,464,190	127,262	538,621	76,989
August	873,916	517,083	1,332,998	159,368	690,035	135,345
September	821,404	490,385	1,328,957	160,625	524,807	141,522
October	858,397	467,660	1,145,354	176,920	590,170	119,585
November	772,725	422,597	1,253,007	189,867	476,908	77,150
December	794,530	467,098	1,250,366	197,557	476,342	81,943

Month.	New York Transit.	Tidewater.	Northern.	Producers and Refiners.	Emery.	Buckeye Macksburg.
January	1,223,796	801,318	577,837	563,433	44,975	677,445
February	1,196,749	847,660	880,895	523,739	46,833	634,508
March	1,270,426	835,170	863,242	533,884	50,303	588,630
April	1,354,005	792,679	782,419	463,997	26,724	526,064
May	1,309,956	842,619	741,626	413,328	23,879	434,885
June	1,245,108	775,264	740,563	371,115	19,625	340,363
July	1,330,409	689,520	937,964	351,258	11,605	255,218
August	1,444,757	766,984	836,368	271,420	8,656	295,549
September	1,619,353	787,752	674,847	255,934	14,618	260,392
October	1,867,433	781,823	628,253	300,896	25,562	394,988
November	1,598,930	809,407	612,676	334,527	24,501	473,226
December	1,443,631	784,982	751,488	347,807	32,499	571,899

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Stocks of petroleum held by eastern pipe lines in the Appalachian field at the end of each month in 1915 and 1915, in barrels—Continued.

1916—Continued.

Month.	Buckeye Lima.	Indiana.	Franklin.	Other lines.	Total.
January	2,467,706	834,097	44,199	1,306,845	12,908,142
February	2,437,318	844,565	46,426	1,240,263	13,044,969
March	2,269,764	826,120	49,279	1,150,771	12,887,208
April	2,229,725	772,180	52,481	1,091,937	12,316,023
May	2,388,713	796,115	55,643	1,068,277	12,141,330
June	2,557,492	851,072	52,086	959,049	11,880,102
July	2,467,430	903,991	49,397	928,364	11,540,587
August	2,465,764	942,966	52,751	962,029	11,755,989
September	2,593,224	857,584	55,054	926,323	11,512,681
October	2,508,030	942,147	51,471	936,200	11,794,339
November	2,638,044	894,833	41,771	945,232	11,565,401
December	2,524,874	840,461	33,715	907,871	11,508,873

Stocks of all grades of petroleum held by eastern pipe lines[a] *in the Appalachian field at end of each month in 1915 and 1916, in barrels.*

Month.	Pennsylvania.[b]	Lima.	Illinois.	Kentucky.	Mid-Continent.	Total.
1915.						
January	5,261,676	1,699,059	1,199,716	322,119	2,775,568	11,258,138
February	5,155,769	1,831,184	1,382,970	331,453	2,763,618	11,464,994
March	5,337,948	1,982,851	1,082,045	233,822	2,915,815	11,552,481
April	5,354,181	2,161,666	876,380	286,864	3,211,513	11,890,604
May	5,148,402	2,359,187	642,987	313,160	3,030,558	11,494,294
June	5,096,191	2,573,005	762,845	272,888	2,838,475	11,543,404
July	5,112,932	2,818,675	1,129,139	227,984	3,437,155	12,725,885
August	4,849,224	2,885,176	1,033,608	251,698	3,264,311	12,284,017
September	5,034,594	2,945,678	990,508	280,550	3,191,595	12,442,925
October	5,036,354	3,021,197	1,262,246	215,111	3,064,874	12,599,782
November	5,199,828	3,011,261	1,308,058	227,234	2,870,210	12,616,591
December	5,488,553	2,918,648	1,550,703	252,943	2,710,207	12,921,054
1916.						
January	5,262,860	2,700,442	1,736,181	276,857	2,931,802	12,908,142
February	5,071,840	2,512,167	2,052,343	302,494	3,106,125	13,044,969
March	5,150,091	2,322,934	1,994,313	239,374	3,180,496	12,887,208
April	4,701,121	2,113,295	1,870,888	255,742	3,374,977	12,316,023
May	4,431,168	2,114,924	1,561,634	331,426	3,702,178	12,141,330
June	3,975,575	2,117,362	1,550,828	309,044	3,927,293	11,880,102
July	3,628,242	2,256,006	1,336,219	300,706	4,019,414	11,540,587
August	3,442,734	2,388,681	1,106,246	355,530	4,462,798	11,755,989
September	3,053,415	2,359,913	1,132,464	364,854	4,602,035	11,512,681
October	3,358,737	2,169,193	1,155,469	383,266	4,727,674	11,794,339
November	3,318,933	2,062,922	1,170,912	402,777	4,609,857	11,565,401
December	3,423,612	2,088,365	1,268,155	425,932	4,300,809	11,508,873

[a] These pipe lines connect with the delivering lines of the Illinois, Kansas, and Oklahoma fields and receive and transfer large quantities of these western oils to the Atlantic seaboard in addition to the oil from the wells directly tributary to their own systems.

[b] Includes natural lubricating oil from Pennsylvania and West Virginia.

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DELIVERIES TO TRADE.

Pipe-line runs and deliveries to trade of petroleum from the Appalachian field in 1915 and 1916 and stocks at end of each month, in barrels.

Month.	1915			1916		
	Runs.	Deliveries.	Stocks.	Runs.	Deliveries.	Stocks.
Dec. 31, 1914			5,724,695			
January	1,898,525	2,039,425	5,583,795	1,735,045	1,936,824	5,539,717
February	1,833,601	1,930,174	5,487,222	1,675,288	1,840,671	5,374,334
March	2,039,101	1,954,553	5,571,770	1,878,543	1,863,412	5,389,465
April	2,002,542	1,933,267	5,641,045	1,852,473	2,285,075	4,956,863
May	1,882,709	2,062,192	5,461,562	2,035,481	2,229,750	4,762,594
June	1,963,778	2,056,261	5,369,079	1,978,564	2,456,539	4,284,619
July	1,944,675	1,972,838	5,340,916	1,905,241	2,260,912	3,928,948
August	1,884,214	2,114,208	5,110,922	2,034,233	2,164,917	3,798,264
September	1,868,186	1,663,964	5,315,144	1,908,448	2,288,443	3,418,269
October	1,831,468	1,895,147	5,251,465	2,045,396	1,721,662	3,742,003
November	1,787,842	1,612,245	5,427,062	2,004,037	2,024,330	3,721,710
December	1,923,407	1,608,973	5,741,496	1,956,706	1,828,872	3,849,544
	22,860,048	22,843,247		23,009,455	24,901,407	

Deliveries to trade by eastern pipe lines[a] in 1915 and 1916, in barrels.

1915.

Month.	National Transit.	Southwest Pennsylvania.	Eureka.	Cumberland.	Southern.	Crescent.
January	458,395	120,500	64,122	278	346,283	120,419
February	371,949	117,846	75,956	18	272,466	109,230
March	397,281	143,502	66,098	21	296,897	173,458
April	433,869	144,985	61,524	584	265,951	154,130
May	405,839	137,312	66,097	1,212	241,779	201,122
June	398,331	127,988	63,565	478	292,982	157,092
July	468,849	159,813	58,692	806	316,980	114,655
August	504,914	164,273	68,848	483	309,123	148,719
September	505,190	156,776	76,229	706	170,439	129,193
October	449,989	147,570	60,791	431	162,561	148,454
November	401,068	149,922	67,464	10,070	227,876	154,373
December	433,698	161,958	69,909	2,833	153,442	120,308
	5,229,372	1,732,445	799,295	17,920	3,056,779	1,731,153

Month.	New York Transit.	Tidewater.	Producers and Refiners.	Emery.	Buckeye Macksburg.	Franklin.
January	274,188	178,867	157,639	27,142	.....	9,476
February	284,859	141,408	132,426	29,482	.....	.....
March	237,321	181,742	149,594	31,559	.....	432
April	328,616	201,715	159,218	26,675	.....	.....
May	411,381	151,359	151,697	27,250	990	.....
June	372,709	242,219	163,657	29,799	1,464	4
July	499,814	142,878	163,602	27,918	.....	1,774
August	692,741	197,585	199,921	19,300	.....	493
September	603,577	200,101	164,024	23,868	.....	661
October	467,694	151,725	181,864	21,699	.....	23,592
November	543,972	135,874	264,274	18,261	.....	22,809
December	592,914	139,256	164,769	23,326	.....	6,360
	5,309,786	2,064,729	2,052,685	306,279	2,454	65,601

[a] These pipe lines connect with the delivering lines of the Illinois, Kansas, and Oklahoma fields and receive and transfer large quantities of these western oils to the Atlantic seaboard in addition to the oil from wells directly tributary to their own systems.

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Deliveries to trade by eastern pipe lines in 1915 and 1916, in barrels—Continued.

1916.

Month.	National Transit.	Southwest Pennsylvania.	Eureka.	Cumberland.	Southern.	Crescent.
January	317,395	142,661	66,617	7,662	237,681	160,024
February	348,172	141,767	69,071	9,414	237,532	151,476
March	357,274	164,198	66,738	13,407	315,658	140,736
April	467,894	168,270	56,865	10,073	309,559	150,387
May	593,618	179,265	82,055	3,206	237,419	165,120
June	523,282	153,488	78,768	2,716	376,795	128,362
July	487,593	164,937	91,059	3,469	310,844	202,985
August	507,656	182,859	82,703	1,235	286,308	94,997
September	438,775	168,416	71,814	4,243	382,152	143,134
October	512,451	134,981	85,458	2,707	291,850	171,364
November	495,946	154,441	81,010	2,399	279,810	192,612
December	437,870	172,383	81,107	3,833	255,317	148,926
	5,487,926	1,927,666	913,265	64,364	3,520,925	1,850,523

Month.	New York Transit.	Tidewater.	Producers and Refiners.	Emery.	Buckeye Macksburg.	Franklin.
January	701,582	169,327	312,794	29,303	.....	578
February	706,043	169,520	192,234	22,874	.....	.....
March	715,160	138,177	175,717	24,129	490	.....
April	759,759	202,215	235,500	52,821	968	.....
May	767,440	117,306	228,267	33,663	1,285	237
June	877,647	193,439	212,262	33,516	4,495	6,761
July	878,902	176,349	183,313	37,271	749	5,619
August	782,886	168,891	246,572	32,379	2,425	.....
September	673,224	152,127	174,513	21,153	1,679	483
October	603,597	156,376	132,016	16,460	3,835	6,398
November	659,727	157,814	177,983	27,173	5,010	12,590
December	735,118	142,973	156,517	18,801	5,120	10,939
	8,861,085	1,944,514	2,427,688	349,543	26,056	43,605

PRICES OF APPALACHIAN OIL.

Prices paid at wells by the Seep Purchasing Agency for petroleum produced in the Appalachian field in 1915 and 1916, per barrel.

1915.

Date.	Pennsylvania and Tiona, Pa.	Mercer black, Pennsylvania and New Castle, Ohio.	Corning, Ohio.	Cleveland, Ohio.	Wooster, Ohio.	Cabell, W. Va.	Somerset, Ky. (light).	Ragland, Ky. (heavy.)
Jan. 1	$1.45	$1.02	$0.85	.....	$1.15	$1.05	$0.85	$0.65
Jan. 4	1.50	1.07	.95	.....	.....	1.10	.90	.70
Feb. 16	.....	.....	.....	.....	1.10	.....	.....	.....
Mar. 15	1.45	1.02	.90	.....	.....	1.05	.85	.65
Mar. 20	1.40	1.00	.85	.....	.....	1.00	.83	.....
Apr. 3	1.35	.97	.83	.....	.....	.97	.80	.63
Apr. 18	.....	.....	.....	.....	1.05	.....	.....	.....
Aug. 13	1.45	1.07	.93	.....	.....	1.07	.90	.....
Aug. 17	1.55	1.17	1.03	.....	.....	1.17	1.00	.65
Aug. 20	.....	.....	.....	.....	1.10	.....	.....	.....
Aug. 23	.....	.....	.....	.....	1.15	.....	.....	.....
Aug. 24	1.60	1.20	1.06	.....	.....	1.20	1.03	.....
Sept. 4	.....	.....	.....	.....	1.20	.....	.....	.....
Sept. 13	1.65	1.23	1.12	.....	.....	1.25	1.08	.....
Sept. 15	.....	.....	.....	$1.25	1.25	.....	.....	.....
Sept. 27	1.70	1.26	1.18	.....	.....	1.30	1.12	.....
Oct. 7	1.75	.....	1.25	.....	.....	.....	1.17	.....
Oct. 23	.....	.....	.....	1.30	.....	.....	.....	.....
Oct. 25	.....	.....	.....	.....	1.30	.....	.....	.....
Oct. 27	1.80	1.30	1.30	.....	.....	.....	1.22	.....
Nov. 5	1.85	1.35	1.35	.....	.....	1.35	1.27	.68
Nov. 15	1.90	1.40	1.40	1.35	1.35	1.40	1.32	.70
Nov. 17	.....	.....	.....	1.40	1.40	.....	.....	.....
Nov. 18	2.00	1.50	1.50	.....	.....	1.50	1.42	.....
Dec. 3	2.10	1.60	1.60	1.45	1.45	1.60	1.50	.....
Dec. 15	.....	.....	.....	1.50	1.50	.....	.....	.....
Dec. 17	2.15	1.65	1.65	.....	.....	1.70	1.55	.72
Dec. 30	2.25	1.75	1.75	.....	.....	1.78	1.63	.75

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Prices paid at wells by the Seep Purchasing Agency for petroleum produced in the Appalachian field in 1915 and 1916, per barrel—Continued.

1916.

Date.	Pennsylvania and Tiona, Pa.	Mercer black, Pennsylvania, and New Castle [a] and Corning, Ohio.	Cleveland, Ohio.	Wooster, Ohio.	Cabell, W. Va.	Somerset, Ky. (light).	Ragland, Ky. (heavy).
Jan. 1	$2.25	$1.75	$1.50	$1.50	$1.78	$1.63	$0.75
Jan. 3			1.60	1.60			
Jan. 6			1.80				
Jan. 22			1.85	1.65			
Jan. 27			1.90	1.70			
Jan. 28	2.35	1.85			1.88	1.73	.80
Feb. 6				1.75			
Feb. 7			1.95				
Feb. 21	2.40	1.90			1.95	1.78	.82
Mar. 6	2.50	2.00			2.02	1.85	.85
Mar. 7			2.00	1.80			
Mar. 16			2.10	1.90			
Mar. 17	2.60	2.10			2.12	1.95	.90
May 19			2.20	2.00			
July 28				1.90			
July 29	2.50	2.00			2.02	1.85	.80
Aug. 1				1.80			
Aug. 3	2.40	1.90			1.92	1.75	.75
Aug. 4				1.70			
Aug. 10	2.35	1.85			1.87	1.70	
Aug. 14				1.65			
Aug. 15	2.30	1.80			1.82	1.65	
Sept. 28	2.40	1.90			1.92	1.75	.80
Oct. 10	2.50	2.00			2.02	1.85	.85
Oct. 20	2.60	2.10			2.12	1.95	.90
Oct. 31						1.90	
Nov. 18				1.70			
Dec. 5	2.75	2.20			2.17	2.00	.95
Dec. 13				1.75			
Dec. 19				1.80			
Dec. 29	2.85	2.30			2.22	2.05	

[a] New Castle was not quoted separately after Oct. 20.

NOTE.—In addition to these prices bonuses ranging from 2 to 10 cents a barrel were paid by various pipe lines and refineries.

Average monthly prices of Appalachian petroleum in 1915 and 1916, per barrel.

1915.

Month.	Pennsylvania and Tiona, Pa.	Mercer black, Pennsylvania and New Castle, Ohio.	Corning, Ohio.	Cleveland, Ohio.	Wooster, Ohio.	Cabell, W. Va.	Somerset, Ky.	Ragland, Ky.
January	$1.50	$1.07	$0.94		$1.15	$1.10	$0.90	$0.70
February	1.50	1.07	.95		1.13	1.10	.90	.70
March	1.45	1.04	.90		1.10	1.05	.86	.67
April	1.35	.97	.83		1.08	.97	.80	.63
May	1.35	.97	83		1.05	.97	.80	.63
June	1.35	.97	.83		1.05	.97	.80	.63
July	1.35	.97	.83		1.05	.97	.80	.63
August	1.47	1.09	.95		1.08	1.09	.92	.64
September	1.64	1.23	1.10	$1.25	1.22	1.24	1.07	.65
October	1.75	1.27	1.24	1.26	1.26	1.30	1.17	.65
November	1.91	1.41	1.41	1.35	1.32	1.41	1.33	.69
December	2.12	1.62	1.62	1.47	1.47	1.64	1.52	.71
Average	1.56	1.14	1.04	1.35	1.16	1.15	.99	.66

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Average monthly prices of Appalachian petroleum in 1915 and 1916—Continued.

1916.

Month.	Pennsylvania and Tiona, Pa.	Mercer, black, Pennsylvania and New Castle and Corning, Ohio.	Cleveland, Ohio.	Wooster, Ohio.	Cabell, W. Va.	Somerset, Ky.	Ragland, Ky.
January	$2.26	$1.76	$1.79	$1.62	$1.79	$1.64	$0.76
February	2.37	1.87	1.94	1.74	1.90	1.75	.81
March	2.53	2.03	2.04	1.84	2.06	1.89	.87
April	2.60	2.10	2.10	1.90	2.12	1.95	.90
May	2.60	2.10	2.14	1.94	2.12	1.95	.90
June	2.60	2.10	2.20	2.00	2.12	1.95	.90
July	2.59	2.09	2.20	1.99	2.11	1.94	.89
August	2.34	1.84	2.20	1.68	1.86	1.69	.75
September	2.31	1.81	2.20	1.65	1.83	1.66	.76
October	2.51	2.01	2.20	1.65	2.03	1.86	.85
November	2.60	2.10	2.20	1.67	2.12	1.90	.90
December	2.74	2.20	2.20	1.75	2.17	1.99	.94
Average	2.51	2.00	2.12	1.79	2.02	1.85	.85

Monthly and yearly average prices of pipe-line certificates of petroleum of Pennsylvania grade at wells in daily market, 1907–1916, per barrel.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
1907	$1.58	$1.61½	$1.72½	$1.78	$1.78	$1.78	$1.78	$1.78	$1.78	$1.78	$1.78	$1.78	$1.745
1908	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.780
1909	1.78	1.78	1.78	1.78	1.70	1.67½	1.60½	1.58	1.58	1.56½	1.49	1.44½	1.646
1910	1.40½	1.40	1.40	1.36½	1.35	1.31½	1.30	1.30	1.30	1.30	1.30	1.30	1.336
1911	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.31	1.301
1912	1.41	1.50	1.50	1.52	1.55	1.59	1.60	1.60	1.60	1.60	1.75	1.96	1.598
1913	2.07	2.49	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.463
1914	2.50	2.50	2.50	2.37	1.93	1.78	1.72	1.54	1.45	1.45	1.45	1.45	1.889
1915	1.50	1.50	1.45	1.35	1.35	1.35	1.35	1.47	1.64	1.75	1.91	2.12	1.563
1916	2.26	2.37	2.53	2.60	2.60	2.60	2.59	2.34	2.31	2.51	2.60	2.74	2.507

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Highest and lowest prices of crude petroleum of Pennsylvania grade, 1859–1916, per barrel.

Year.	Highest.		Lowest.	
	Month.	Price.	Month.	Price.
1859	September	$20.00	December	$20.00
1860	January	20.00	do	2.00
1861	do	1.75	do	.10
1862	December	2.50	January	.10
1863	do	4.00	do	2.00
1864	July	14.00	February	3.75
1865	January	10.00	August	4.00
1866	do	5.50	December	1.35
1867	October	4.00	June	1.50
1868	July	5.75	January	1.70
1869	January	7.00	December	4.25
1870	do	4.90	August	2.75
1871	June	5.25	January	3.25
1872	October	4.55	December	2.67½
1873	January	2.75	November	.82½
1874	February	2.25	do	.62½
1875	do	1.82½	January	.75
1876	December	4.23½	do	1.47½
1877	January	3.69½	June	1.53½
1878	February	1.87½	September	.78½
1879	December	1.28½	June	.63½
1880	June	1.24½	April	.71½
1881	September	1.01½	July	.72½
1882	November	1.37	do	.49½
1883	June	1.24½	January	.83½
1884	January	1.15½	June	.51½
1885	October	1.12½	January	.68
1886	January	.92½	August	.59½
1887	December	.90	July	.54
1888	March	1.00	June	.71½
1889	November	1.12½	April	.79½
1890	January	1.07½	December	.60½
1891	February	.81½	August	.50
1892	January	.64½	October	.50
1893	December	.80	January	.52½
1894	do	.95½	do	.78½
1895	April	2.60	do	.95½
1896	January	1.50	December	.90
1897	March	.96	October	.65
1898	December	1.19	January	.65
1899	do	1.66	February	1.13
1900	January	1.68	November	1.05
1901	January, September	1.45	May	.80
1902	December	1.54	January, February, March	1.15
1903	do	1.90	January, February, March, April, May, June, July.	1.50
1904	January	1.85	July, December	1.50
1905	October	1.61	May	1.27
1906	April, May, June, July	1.64	January, February, March, April, August, September, October, November, December.	1.58
1907	March to December, inclusive	1.78	January	1.58
1908	No change	1.78	No change	1.78
1909	January, February, March	1.78	December	1.43
1910	January	1.43	June to December, inclusive	1.30
1911	December	1.35	January to December	1.30
1912	do	2.00	January	1.35
1913	March to December, inclusive	2.50	do	2.00
1914	January to March, inclusive	2.50	September to December, inclusive	1.45
1915	December	2.25	April to August, inclusive	1.35
1916	do	2.85	January	2.25

SUMMARY OF WELLS DRILLED IN APPALACHIAN FIELDS.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on pages 705–706, which were taken from reports received directly from the oil producers.

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Wells completed in the Appalachian field, 1912–1916.

State.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Pennsylvania and New York	1,911	3,420	2,247	1,409	2,500	322	521	338	284	296	2,472	4,251	2,869	1,906	3,051
Southeastern and central Ohio	846	1,246	863	677	927	460	603	517	472	525	1,717	2,191	2,044	1,910	1,854
West Virginia	1,062	1,285	1,043	763	1,055	234	339	347	246	296	1,657	2,065	1,758	1,289	1,793
Kentucky	112	133	119	56	878	61	69	55	36	179	178	210	178	92	1,074
Tennessee	.....	.....	.....	4	2	.....	.....	.....	7	7	.....	.....	.....	12	9
	3,931	6,084	4,272	2,909	5,362	1,077	1,532	1,257	1,045	1,303	6,024	8,717	6,849	5,209	7,781

[a] Including gas wells.

Oil wells and dry holes drilled in the Appalachian field in 1916.

State.	January.		February.		March.		April.		May.		June.		July.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Pennsylvania and New York	143	21	152	23	115	24	164	29	237	26	267	28	288	30
Southeastern and central Ohio	66	40	56	41	60	37	74	44	97	53	92	48	101	51
West Virginia	66	17	79	11	71	18	78	23	78	27	97	40	96	28
Kentucky	48	7	25	7	30	8	35	6	51	15	48	3	104	15
Tennessee	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5
	323	87	312	82	276	87	351	102	463	121	504	119	591	129

State.	August.		September.		October.		November.		December.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Pennsylvania and New York	256	27	231	21	236	14	208	17	203	36	2,500	296
Southeastern and central Ohio	89	51	77	44	71	33	64	43	80	40	927	525
West Virginia	99	24	94	32	111	23	92	31	92	22	1,055	296
Kentucky	94	25	121	31	123	30	96	12	103	20	878	179
Tennessee	.....	.....	1	.....	.....	.....	1	.....	.....	.....	2	7
	538	127	524	128	541	100	461	103	478	118	5,362	1,303

Wells completed in the Appalachian field, 1912–1916.

Month.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
January	182	317	445	185	323	73	96	117	89	87	311	513	649	408	503
February	173	319	364	164	312	43	111	133	74	82	260	528	574	367	485
March	223	394	321	211	276	82	106	88	84	87	360	585	464	395	439
April	300	466	524	224	351	65	126	137	75	102	427	675	734	390	514
May	316	541	531	237	463	78	112	141	87	121	491	727	770	407	668
June	397	632	489	214	504	79	139	135	93	119	573	829	734	382	723
July	386	569	463	237	591	98	139	121	88	129	570	786	738	411	812
August	429	595	375	251	538	121	155	113	104	127	636	846	615	455	773
September	396	580	198	238	524	140	142	76	84	128	670	814	427	415	763
October	386	601	197	312	541	102	132	70	86	100	622	855	388	508	731
November	352	565	177	337	461	100	121	69	113	103	562	798	385	588	683
December	361	506	188	299	478	96	153	57	78	118	542	766	371	483	687
	3,931	6,084	4,272	2,909	5,362	1,077	1,532	1,257	1,045	1,303	6,024	8,717	6,849	5,209	7,781

[a] Including gas wells.

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Initial daily production of new wells in the Appalachian field in 1916, in barrels.

State.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Pennsylvania and New York	814	1,429	348	924	632	754	775	740	578	964	510	2,306	10,774
Southeastern and central Ohio	770	696	439	1,355	817	1,163	896	1,066	779	994	897	966	10,838
West Virginia	891	833	795	1,502	1,451	2,621	1,965	1,265	1,933	3,678	4,047	3,253	21,234
Kentucky	660	517	779	1,281	1,123	2,114	3,678	3,659	3,412	3,331	3,227	3,529	27,310
Tennessee	.....	.....	.....	.....	.....	.....	.....	.....	25	.....	20	.....	45
	3,135	3,475	2,361	5,062	4,023	6,652	7,314	6,730	6,727	8,967	8,701	10,054	73,201

Total and average initial daily production of new wells in the Appalachian field, 1912–1916, by States, in barrels.

State.	Total initial production.					Average per well.				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Pennsylvania and New York	6,771	8,958	6,627	9,320	10,774	3.5	2.6	3.0	6.6	4.3
Southeastern and central Ohio	24,193	16,302	12,047	8,373	10,838	28.6	13.1	14.0	12.4	11.7
West Virginia	109,804	34,835	24,474	13,501	21,234	103.4	27.1	23.5	17.7	23.0
Kentucky	1,943	2,215	1,568	728	27,310	17.4	16.1	13.2	13.0	31.1
Tennessee	.....	.....	.....	250	45	.....	.....	.....	62.5	22.5
	142,711	62,310	44,716	32,172	73,201	36.3	10.2	10.5	11.1	13.7

Total initial daily production of new wells in the Appalachian field, 1912–1916, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1912	4,417	10,835	11,523	18,781	22,986	22,836	16,199	9,751	6,466	6,758	4,251	7,908	142,711	11,893
1913	4,768	5,816	5,223	6,283	4,510	7,464	4,412	5,162	4,423	5,626	4,557	4,066	62,310	5,193
1914	4,787	4,256	4,452	4,190	5,141	4,312	4,102	3,420	2,256	3,776	1,976	2,048	44,716	3,726
1915	2,537	1,794	2,415	2,040	2,433	2,523	3,283	3,077	2,697	2,348	3,731	3,014	31,922	2,660
1916	3,135	3,475	2,361	5,062	4,023	6,652	7,314	6,730	6,727	8,967	8,701	10,054	73,201	6,100

PENNSYLVANIA.

GENERAL STATEMENT.

Peculiar interest attaches to the production of petroleum in Pennsylvania as a consequence of the fact that the petroleum industry of the United States had its inception in this State and of the further fact that the oil pools opened in the early sixties near Titusville, Crawford County, are still contributors to the oil supply of the country. Pennsylvania has been a regular and reliable factor in the petroleum industry of the United States since 1859, though its annual output of oil has generally declined since 1891, at an average rate of about 3 per cent a year. The output in 1916, which was 7,592,394 barrels, was 3 per cent less than the output in 1915 and was only 24 per cent of the output in 1891.

The average price per barrel received for the oil marketed in 1916 was $2.52, and the market value of the entire output was $19,149,855, a gain of 94 cents a barrel and of $6,718,502, or 54 per cent, in gross market value, compared with 1915. The average price received for

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crude oil in Pennsylvania in 1916 was greater than that in any other year since 1876, when the average price for the year was $2.56 a barrel. Toward the end of 1916 advanced cost and increasing scarcity of drilling supplies, principally casing, tended to retard field operations in all districts.

DEVELOPMENT.

Inclusive of the New York portion of the Bradford district a total of 2,827 new wells were completed in Pennsylvania in 1916, an increase of 1,019 compared with 1915, and of 225 compared with 1914. The results of drilling in 1916 include 2,298 oil wells, 242 gas wells, and 287 wells (an average of about 1 in 10) that were barren of either. The combined output for the first day of productive life of all oil wells completed in Pennsylvania in 1916 is estimated to have been 10,367 barrels, an average of 4.5 barrels per well. That the State average is not decidedly lower than indicated is due solely to the success of operations in the southwestern district, which was the only district that consistently furnished wells averaging in initial capacity more than 3.3 barrels.

Bradford district.—In the old Bradford district 509 wells were completed, including 485 oil wells, 13 gas wells, and only 11 dry holes. The ratio of one to 47 between dry holes and total completions indicates the large extent to which drilling operations were restricted to proved territory. The average initial yield of the new oil wells was 3.3 barrels, the same as in 1915.

Middle district.—In the oil fields of Warren, Elk, and Forest counties 262 wells were completed in 1916. This total includes 234 oil wells, credited with an average output of 1.8 barrels each the first 24 hours after completion, 8 gas wells, and 20 dry holes. The Ridgway gas field, in Elk County, received a fair amount of attention, which was rewarded by the completion of a number of gas wells of large capacity. At Glenhazel, several miles northeast of Ridgway, considerable interest was aroused in August by the completion of a 40-barrel oil well in territory where wells of 2 or 3 barrels initial capacity are the rule.

Near Kinzua, on the eastern edge of Warren County, the completion of a 15-barrel oil well in November inspired a quest for oil on surrounding acreage. Wildcat activity about the borders of this district were credited with the discovery of oil in small quantities on the Howe estate, 6 miles southeast of Corry, Erie County.

Venango-Clarion district.—More wells were drilled in 1916 in the pioneer oil district of Pennsylvania than in any other district in the State. Of 1,105 wells completed, 955, or 86 per cent, yielded an average initial output of 1.7 barrels of oil each, 67 were gassers, and 83, an average of about 1 in 13, were barren.

Diminishing supply of gas led to considerable activity in the search for gas in the Clarion gas belt where the bulk of the drilling for this fuel was in Clarion and Limestone townships. At the north end of this district there was a revival of activity in the area about Titusville, where a number of new wells of small capacity were completed in the territory that received its first development in the months following the completion of the historic Drake well in August, 1859. Farther south near Emlenton, Venango County, the drilling in of a 100-barrel well on the Rumbarger farm, in May, resulted in the

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development of a small extension to the old Red Valley pool in Rockland Township. To the east of this district, in Jefferson County, wildcat drilling resulted in the discovery, in November, of oil in small quantities near Corsica.

Butler-Armstrong district.—Field operations in the Butler-Armstrong district, which attracted so much attention in 1915, were slightly greater in 1916 than in 1915. In all, 339 wells were completed in 1916, as compared with 324 in 1915. Of the wells drilled in 1916, 239 yielded an average initial flow of 3 barrels of oil each, 43 were gas wells, and 57, an average of 3 in every 18 completed, were barren.

The Evans City field in Butler County, so actively drilled in 1915, received further attention in 1916, which was centered in the development of two pools of oil in the Hundred-foot sand, to the northwest and southeast, respectively, of the Third sand pool developed within the borough limits in 1915. Further incentive to active drilling in Butler County was provided by the opening of territory capable of furnishing wells above the average capacity of those found in this district on the Donnelly heirs' tract, a mile northwest of Hilliards, and on the Milford farm, east of Annisville, in both of which localities production was derived from the Hundred-foot sand.

Southwestern district.—In the southwestern counties of Pennsylvania 612 wells were completed in 1916, compared with 359 in 1915. Of these 385, or 63 per cent, produced an average initial flow of 16 barrels of oil each, 111 were gas wells, and 116, an average of 2 in 11, were barren. At different times during the year activity in drilling was centered in the old Burgettstown pool, Hanover Township, Washington County; at Ingomar, Duff City, and Dorseyville, Allegheny County; at Dunns Station, Washington County; and in the old Bessemer field, Lawrence County, in the intensive development of small areas that had not been drained in the course of the earlier development in these localities. The completion in December of an oil well on the George Isiminger farm, in Springhill Township, Green County, was the most significant development of the year. This well was credited with an initial flow of 200 barrels of oil a day and inspired additional drilling that resulted in the development in 1917 of an important new pool of oil in the Gordon sand, reached, in this locality, at depths between 3,300 and 3,400 feet.

After a nine months' quest for lost tools, drilling was resumed in May, 1917, at a depth of 7,333 feet, on the deep test, at McDonald, Washington County, begun in November, 1911, by the Peoples Natural Gas Co.

NEW YORK.

Little change is apparent from year to year in the status of the petroleum industry in New York. The steady decline in production that has characterized the trend of the industry in this State in recent years was continued in 1916, though the stimulation to field activity provided by advancing prices in the closing months of 1915 and the early months of 1916, and again during the closing months of the latter year, served to retard appreciably the usual decline. Thus the output of 874,087 barrels of petroleum from the New York fields in 1916 was a decrease of only 2 per cent from the output in 1915, whereas the output in 1915 was 5 per cent less than in 1914. The

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average price received at the wells for the petroleum marketed in New York in 1916 was $2.51 a barrel, and the total market value of the output was $2,190,195, a gain of 94 cents in average unit price and of $799,870, or 57.5 per cent, in gross market value over 1915.

No important developments resulted from drilling in the oil fields of western New York in 1916. The completion in March of a successful oil well, on the Fitzgerald farm, 3 miles southeast of Wellsville, Allegany County, resulted in the development along Trapping Brook of a small pool of high-grade oil, derived from the Scio sand. In the entire Allegany district 224 wells, more than double the number drilled in 1915, were completed in 1916. Of these, 202 produced an average of 2 barrels each the first 24 hours after completion, 13 produced gas only, and only 9, an average of about 1 in 25, were barren.

Wildcat drilling was continued during 1916 in the area to the east and north of the Allegany district. Deep wells were drilled within the city limits both of Hornell and of Rochester, without success so far as oil is concerned, although gas in small quantities was obtained at several horizons in the Hornell well.

Statistics of drilling activity in the New York portion of the Bradford district are included with those relating to the Pennsylvania portion of that district.

COMBINED STATISTICS OF PENNSYLVANIA AND NEW YORK FIELDS.

MARKETED PRODUCTION.

Petroleum marketed in Pennsylvania and New York, 1912–1916, in barrels.

Pennsylvania.

Month.	1912	1913	1914	1915	1916
January	562,665	669,134	677,284	629,588	625,720
February	575,180	577,763	532,826	615,005	555,410
March	686,178	637,250	726,605	672,343	625,987
April	699,856	703,829	782,378	697,036	662,241
May	728,127	700,585	701,685	638,490	701,435
June	657,545	661,542	724,172	683,410	658,195
July	678,789	688,055	731,080	682,583	641,148
August	675,848	653,090	646,412	655,242	663,901
September	634,114	651,046	688,761	654,036	609,754
October	686,184	693,996	704,024	645,333	638,244
November	610,314	609,033	614,126	623,956	605,049
December	643,148	671,979	640,982	641,084	606,310
	7,837,948	7,917,302	8,170,335	7,838,705	7,592,394

New York.

January	64,850	80,906	78,983	74,101	72,216
February	63,080	66,969	62,424	67,755	61,611
March	73,371	74,592	80,660	79,840	64,909
April	79,188	82,580	88,268	79,018	79,439
May	82,035	83,742	84,548	75,114	80,140
June	73,950	77,819	84,110	76,408	78,586
July	75,875	83,237	84,783	79,012	76,489
August	74,663	78,005	75,512	72,531	76,552
September	68,884	78,594	76,102	72,914	72,946
October	76,766	84,480	81,569	72,390	73,056
November	68,045	74,437	71,593	66,218	68,351
December	73,421	82,830	70,422	72,468	69,792
	874,128	948,191	938,974	887,778	874,087

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SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on page 705, which are obtained from reports received directly from the oil producers.

Wells completed in Pennsylvania and New York, 1912–1916.

District.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Allegany	177	441	215	76	202	17	22	17	4	9	246	509	267	98	224
Bradford	335	675	455	313	485	14	31	28	11	11	371	755	531	348	509
Middle	226	352	207	159	234	36	66	17	16	20	266	435	230	182	262
Venango and Clarion	853	1,352	813	458	955	90	141	68	66	83	1,019	1,578	936	595	1,105
Butler and Armstrong	138	354	183	224	239	59	110	81	84	57	216	497	284	324	339
Southwestern Pennsylvania	182	246	374	179	385	106	151	127	103	116	354	477	621	359	612
	1,911	3,420	2,247	1,409	2,500	322	521	338	284	296	2,472	4,251	2,869	1,906	3,051

[a] Including gas wells.

Oil wells and dry holes drilled in Pennsylvania and New York in 1916.

District	January.		February.		March.		April.		May.		June.		July.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Allegany	6	.....	7	.....	3	.....	18	.....	20	1	31	.....	23	2
Bradford	28	1	33	2	18	1	27	1	54	1	55	.....	52	.....
Middle	22	1	11	1	11	1	13	.....	30	2	21	1	26	2
Venango and Clarion	52	7	60	9	52	5	72	8	88	10	94	10	103	8
Butler and Armstrong	21	2	14	2	19	8	19	9	25	5	25	10	16	5
Southwestern Pennsylvania	14	10	18	9	12	9	15	11	20	7	41	7	68	13
	143	21	152	23	115	24	164	29	237	26	267	28	288	30

District.	August.		September.		October.		November.		December.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Allegany	21	2	21	1	19	.....	18	2	15	1	202	9
Bradford	49	1	46	2	39	.....	43	.....	41	2	485	11
Middle	26	3	19	2	22	.....	12	2	21	5	234	20
Venango and Clarion	91	5	78	3	99	8	83	3	74	7	955	83
Butler and Armstrong	27	3	24	1	17	1	17	6	15	5	239	57
Southwestern Pennsylvania	42	13	43	12	40	5	35	4	37	16	385	116
	256	27	231	21	236	14	208	17	203	36	2,500	296

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Wells completed in Pennsylvania and New York, 1912–1916.

Month.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
January	73	153	220	75	143	21	26	29	18	21	112	205	271	104	178
February	71	129	164	67	152	11	27	37	17	23	91	183	216	103	186
March	90	204	139	95	115	19	36	24	14	24	125	268	179	114	155
April	150	248	303	105	164	23	48	39	17	29	190	329	355	135	213
May	181	333	286	101	237	30	37	42	26	26	232	363	366	151	293
June	210	375	286	99	267	29	49	42	24	28	266	439	358	138	322
July	191	352	273	123	288	28	53	30	29	30	237	431	340	172	340
August	224	344	209	132	256	42	57	22	33	27	284	427	261	190	305
September	190	335	115	116	231	37	56	24	38	21	252	416	163	172	271
October	190	356	94	182	236	26	45	18	26	14	242	431	133	228	281
November	167	341	83	179	208	37	37	17	28	17	228	406	123	230	248
December	174	280	75	135	203	19	50	14	14	36	213	353	106	169	259
	1,911	3,429	2,247	1,409	2,500	322	521	338	284	296	2,472	4,251	2,869	1,906	3,051

[a] Including gas wells.

Total daily production of new wells completed in Pennsylvania and New York in 1916, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Allegany	11	15	6	28	30	61	41	45	31	39	37	63	407
Bradford	101	113	86	94	183	170	142	144	152	116	122	173	1,596
Middle	34	22	13	13	46	43	43	46	60	43	22	36	421
Venango and Clarion	82	89	100	126	153	153	197	134	124	158	134	134	1,584
Butler and Armstrong	55	52	86	90	73	78	33	61	47	72	36	30	713
Southwestern Pennsylvania	531	1,138	57	573	147	249	319	310	164	536	159	1,870	6,053
	814	1,429	348	924	632	754	775	740	578	964	510	2,306	10,774

Total and average initial daily production of new wells in Pennsylvania and New York, 1912–1916, by districts, in barrels.

District.	Total initial production.					Average per well.				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Allegany	278	820	446	122	407	1.6	1.9	2.1	1.6	2.0
Bradford	817	1,676	1,588	1,019	1,596	2.4	2.5	3.5	3.3	3.3
Middle	511	649	586	354	421	2.3	1.8	2.8	2.2	1.8
Venango and Clarion	1,943	2,301	1,263	629	1,584	2.3	1.7	1.6	1.4	1.7
Butler and Armstrong	696	1,487	684	4,288	713	5.0	4.2	3.7	19.1	3.0
Southwestern Pennsylvania	2,526	2,025	2,060	2,908	6,053	13.9	8.2	5.5	16.2	15.7
	6,771	8,958	6,627	9,320	10,774	3.5	2.6	2.9	6.6	4.3

Total initial daily production of new wells in Pennsylvania and New York, 1912–1916, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1912	548	621	613	657	531	588	482	637	720	530	474	370	6,771	564
1913	426	387	733	638	729	959	838	860	826	891	869	802	8,958	746
1914	618	527	476	928	764	706	741	727	300	247	334	259	6,627	552
1915	208	216	234	275	405	969	1,527	1,726	830	921	1,440	569	9,320	777
1916	814	1,429	348	924	632	754	775	740	578	964	510	2,306	10,774	898

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WEST VIRGINIA.

GENERAL STATEMENT.

Despite improved market conditions and an extensive drilling campaign, the quantity of petroleum marketed from the oil fields of West Virginia in 1916 was less than in 1915. The output in 1916 was 8,731,184 barrels, a quantity less by 533,614 barrels, or 6 per cent, than in 1915. The reason for this decrease lies in the smaller capacity of the new wells drilled in proved territory and in the failure of wildcat operations to discover new pools that could be developed with sufficient rapidity to offset the steady decline in production in the older districts.

The average price received at the wells for the oil produced in 1916 was $2.51 a barrel and the market value of the entire output was $21,914,080, a gain of 95 cents in average unit price and of $7,445,802, or 51 per cent, in total market value, compared with 1915. Although the output of petroleum in West Virginia in 1916 was less than in any other year since 1895, its market value was considerably larger than in any other year in the history of the local industry, except 1900, in which year, however, the production was 16,195,675 barrels, nearly double the output in 1916.

DEVELOPMENT.

In West Virginia 1,793 wells were completed in 1916, a gain of 504, or 39 per cent, over 1915. Of these 1,055, or 59 per cent, were oil wells credited with an average initial yield of 23 barrels each a day, 442 were gas wells, and 296, an average of 1 in 6, were failures.

Field work for oil in West Virginia in 1916 included 16 counties in its scope. Marion County led with 533 completions, which included 228 oil wells credited with an average initial flow of 53 barrels each and with a combined initial output of 12,163 barrels. This quantity was nearly double the new production obtained in any other county in West Virginia, and was nearly four times the quantity of new production obtained in Marion County in 1915. This increase was due to the discovery and partial development of a rich pool of oil in the 30-foot sand on Dents Run, near Mannington. The discovery well was completed on the Higginbotham farm early in June by J. J. Allen & Co. and was credited with an initial flow of 1,500 barrels. Other wells of even larger initial capacity were completed on the Batson farm northwest of the discovery well in the subsequent development of the pool, which lies about 2 miles north of the old Pitzer pool, developed about 12 years ago.

In Kanawha County interest in development work in the Berea-sand pool on Long Bottom Run, Cabin Creek district, was well sustained throughout the year. Activity in drilling was increased as a consequence of the proof of both a northeastward and a southwestward extension of this pool beyond the limits of the territory controlled by the company that discovered the pool late in 1914.

The discovery of oil in the Big Injun sand in a test well drilled in May, near Grantsville, Sherman district, Calhoun County, resulted in the drilling of other wells in the same locality, which, however, failed to obtain petroleum in commercial quantities.

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Late in 1916 considerable interest was aroused by the finding of oil in commercial quantities in the Dunkard sand in a wildcat test, on the farm of W. D. Lewis, 5 miles east of Charleston, Kanawha County. Other tests were started in the locality before the end of the year.

The stringency in the supply of casing and other drilling materials served to increase greatly the prices of such of these requisites as could be obtained and was felt in West Virginia as early as July, and before the end of the year many wells of small capacity had been abandoned in the quest for casing for new ones.

MARKETED PRODUCTION.

Petroleum marketed in West Virginia, 1912–1916, in barrels.

Month.	1912	1913	1914	1915	1916
January	694,619	978,401	855,886	777,702	647,805
February	801,699	936,733	770,300	754,034	672,843
March	983,502	970,900	919,377	848,926	751,018
April	1,018,955	1,026,129	900,998	801,046	674,056
May	1,153,945	1,003,425	864,519	767,685	765,938
June	1,172,331	995,098	872,074	789,545	737,701
July	1,174,367	1,009,383	897,065	780,749	704,071
August	1,190,552	939,479	272,098	761,111	749,881
September	981,052	928,610	675,518	752,751	706,416
October	1,013,980	956,772	985,724	716,638	783,475
November	918,313	893,274	799,728	720,267	786,723
December	1,025,647	983,095	866,746	794,344	751,257
	12,128,962	11,567,299	9,680,033	9,264,798	8,731,184

Petroleum marketed in West Virginia, 1907–1916, in barrels.

Year.	Regular crude.			Lubricating.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1907	9,089,839	$15,834,714	$1.740	5,457	$17,714	$3.25	9,095,296	$15,852,428	$1.743
1908	9,519,875	16,902,968	1.775	3,301	8,897	2.70	9,523,176	16,911,865	1.776
1909	10,742,026	17,634,335	1.642	3,066	7,948	2.59	10,745,092	17,642,283	1.642
1910	11,751,018	15,717,796	1.338	2,053	5,748	2.80	11,753,071	15,723,544	1.338
1911	9,792,324	12,757,861	1.302	3,140	9,432	3.00	9,795,464	12,767,293	1.303
1912	12,126,137	19,919,952	1.643	2,825	7,769	2.75	12,128,962	19,927,721	1.643
1913	11,562,730	28,813,822	2.492	4,569	14,982	3.28	11,567,299	28,828,814	2.492
1914	9,677,553	18,462,175	1.908	2,480	6,365	2.56	9,680,033	18,468,540	1.908
1915	9,260,914	14,458,513	1.561	3,884	9,765	2.51	9,264,798	14,465,278	1.561
1916	8,727,930	21,904,236	2.510	3,254	9,844	3.03	8,731,184	21,914,080	2.510

SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on page 705, which are obtained from reports received directly from the oil producers.

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Wells completed in West Virginia, 1912–1916.

County.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Brooke	5	28	15	4	5	4	6	16	10	12	9	38	40	21	22
Cabell	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....	.....	.....
Calhoun	19	18	5	3	5	12	6	6	1	16	38	32	17	10	26
Clay	.....	.....	9	14	17	.....	.....	4	.....	2	.....	.....	16	17	23
Gilmer	.....	.....	12	15	.....	.....	.....	8	10	.....	.....	.....	23	32	.....
Hancock	5	21	16	5	5	11	7	6	7	6	16	33	23	13	12
Kanawha	440	177	114	86	170	11	20	17	6	8	486	227	153	105	187
Lincoln	61	66	59	88	124	1	4	8	.....	3	70	75	105	96	137
Marion	80	230	311	181	228	39	51	81	33	67	298	526	535	357	533
Marshall	.....	.....	7	.....	3	.....	.....	3	2	1	.....	.....	18	9	7
Pleasants	59	108	74	71	85	31	42	25	24	51	91	150	102	109	139
Ritchie	79	129	125	53	116	20	39	49	49	23	121	191	190	117	160
Roane	147	253	115	64	74	13	21	15	16	5	169	295	152	99	92
Wetzel and Tyler	66	105	81	97	117	48	61	48	50	61	183	242	199	185	305
Wirt	17	49	53	53	63	3	8	24	15	16	21	60	78	72	81
Wood	61	71	47	25	43	20	36	16	15	25	81	108	63	41	68
Miscellaneous	23	30	.....	4	.....	21	37	21	8	.....	74	87	44	15	1
	1,062	1,285	1,043	763	1,055	234	339	347	246	296	1,657	2,065	1,758	1,289	1,793

[a] Including gas wells.

Oil wells and dry holes drilled in West Virginia in 1916.

County.	January.		February.		March.		April.		May.		June.		July.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Brooke	.....	.....	.....	1	1	2	.....	3	1	2	1	1	1	2
Calhoun	.....	1	.....	.....	.....	.....	.....	1	.....	1	2	.....	.....	4
Clay	1	.....	2	.....	.....	.....	.....	.....	2	.....	1	1	2	.....
Hancock	.....	1	.....	.....	.....	.....	.....	1	.....	1	1	1	1	.....
Kanawha	7	1	10	1	11	1	14	.....	13	.....	12	3	20	.....
Lincoln	5	.....	12	.....	9	.....	15	1	5	.....	16	1	14	.....
Marion	13	4	23	2	12	1	17	3	17	5	18	7	19	7
Marshall	.....	.....	.....	.....	.....	.....	1	.....	1	1	.....	.....	.....	.....
Pleasants	10	3	8	1	8	3	3	6	9	6	7	10	3	4
Ritchie	10	1	3	1	8	2	8	2	8	1	10	.....	9	2
Roane	4	1	7	.....	5	1	6	.....	2	.....	6	2	8	.....
Wetzel and Tyler	9	5	10	4	9	3	6	2	13	6	14	8	11	3
Wirt	3	.....	2	1	4	2	6	2	6	1	3	2	8	3
Wood	4	.....	2	.....	4	3	2	2	1	3	6	4	2	3
	66	17	79	11	71	18	78	23	78	27	97	40	98	28

County.	August.		September.		October.		November.		December.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Brooke	1	.....	.....	1	.....	.....	.....	.....	.....	.....	5	12
Calhoun	.....	.....	1	4	1	2	1	2	.....	1	5	16
Clay	2	.....	.....	.....	2	.....	3	1	2	.....	17	2
Hancock	.....	.....	2	1	.....	.....	.....	1	1	.....	5	6
Kanawha	14	.....	16	1	18	.....	17	1	18	.....	170	8
Lincoln	12	.....	9	.....	11	.....	9	.....	7	1	124	3
Marion	19	8	19	5	24	7	18	11	29	7	228	67
Marshall	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	3	1
Pleasants	5	6	9	6	8	3	9	2	6	1	85	51
Ritchie	16	1	12	1	12	3	5	5	15	4	116	23
Roane	10	1	7	.....	6	.....	8	.....	5	.....	74	5
Wetzel and Tyler	11	6	9	9	10	4	13	4	2	7	117	61
Wirt	4	1	10	2	9	1	8	1	.....	.....	63	16
Wood	5	1	.....	2	9	3	1	3	7	1	43	25
	99	24	94	32	111	23	92	31	92	22	1,055	296

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Wells completed in West Virginia, 1912–1916.

Month.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
January	54	92	109	54	66	18	21	31	26	17	96	157	165	102	121
February	50	98	102	55	79	14	26	38	24	11	80	157	174	99	121
March	71	91	95	63	71	30	30	33	27	18	119	157	151	110	121
April	75	113	95	56	78	15	25	37	18	23	113	177	165	98	125
May	74	103	137	76	78	12	25	45	16	27	116	163	202	114	153
June	90	138	101	60	97	11	34	37	22	40	134	202	174	99	141
July	103	102	95	60	98	18	30	29	20	28	148	163	156	110	162
August	113	110	82	65	99	23	32	29	18	24	171	175	154	100	169
September	117	104	48	66	94	21	30	20	17	32	185	172	108	100	172
October	96	114	58	63	111	21	28	11	21	23	167	187	97	111	164
November	111	109	54	73	92	15	31	15	25	31	162	173	104	128	173
December	108	111	67	72	92	36	27	22	12	22	166	182	108	118	149
	1,062	1,285	1,043	763	1,055	234	339	347	246	296	1,657	2,065	1,758	1,289	1,793

[a] Including gas wells.

Initial daily production of new wells completed in West Virginia in 1916, in barrels.

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Brooke	.....	.....	1	.....	5	5	5	4	.....	.....	.....	.....	20
Calhoun	.....	.....	.....	.....	.....	32	.....	.....	2	5	1	.....	40
Clay	30	8	.....	.....	10	5	8	11	.....	10	26	23	128
Hancock	.....	.....	.....	.....	.....	2	20	.....	8	.....	.....	3	33
Kanawha	285	167	393	568	630	331	700	287	625	742	954	830	6,512
Lincoln	35	87	49	95	31	109	91	92	79	111	83	48	910
Marion	248	190	108	556	342	1,866	763	441	813	2,265	2,886	1,986	12,163
Marshall	.....	.....	.....	3	3	.....	.....	.....	.....	5	.....	.....	11
Pleasants	76	86	73	15	102	37	52	61	41	63	27	61	694
Ritchie	67	54	50	32	53	45	77	152	105	138	30	202	1,005
Roane	20	86	22	55	8	29	61	72	65	52	96	55	621
Wetzel and Tyler	97	120	65	90	220	103	146	131	74	88	95	13	1,242
Wirt	26	15	21	55	42	29	35	6	121	142	149	.....	641
Wood	7	20	13	34	5	28	7	8	.....	87	3	32	214
	891	833	795	1,502	1,451	2,621	1,965	1,265	1,933	3,678	4,047	3,253	24,234

Total and average initial daily production of new wells in West Virginia, 1912–1916, by counties, in barrels.

County.	Total initial production.					Average per well.				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Brooke	19	1,329	186	17	20	3.8	47.5	12.4	4.3	4.0
Cabell	(a)	12	.....	.....	.....	.....	.....	.....	.....	.....
Calhoun	340	199	22	8	40	17.9	11.1	4.4	2.7	8.0
Clay	(a)	(a)	84	261	128	.....	.....	9.3	18.6	7.5
Gilmer	.....	.....	71	109	.....	.....	.....	5.9	7.3	.....
Hancock	21	82	105	32	33	4.2	3.9	6.6	6.4	6.6
Kanawha	98,870	10,703	8,965	4,724	6,512	224.7	60.5	78.6	54.9	38.3
Lincoln	1,058	929	797	821	910	17.3	14.1	13.5	9.3	7.3
Marion	2,001	6,829	9,532	3,163	12,163	25.0	29.7	30.6	17.5	53.3
Marshall	.....	.....	92	.....	11	.....	.....	13.1	.....	3.7
Pleasants	930	2,045	455	551	694	15.8	18.9	6.1	7.8	8.2
Ritchie	726	968	1,545	536	1,005	9.2	7.5	12.4	10.1	8.7
Roane	3,161	9,185	931	696	621	21.5	36.3	8.1	10.9	8.3
Wetzel and Tyler	1,292	1,695	1,085	2,027	1,242	19.6	16.1	13.4	20.9	10.6
Wirt	105	212	437	410	641	6.2	4.3	8.2	7.7	10.2
Wood	318	482	167	76	214	5.2	6.8	3.6	3.0	5.0
Miscellaneous	963	165	.....	70	.....	41.9	5.5	.....	17.5	.....
	109,804	34,835	24,474	13,501	24,234	103.4	27.1	23.5	17.7	23.0

[a] Included in "Miscellaneous."

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Total initial daily production of new wells in West Virginia, 1912–1916, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1912.....	2,010	6,602	8,577	15,925	19,930	19,926	13,528	6,383	4,586	3,901	2,696	5,740	109,804	9,150
1913.....	3,428	3,988	3,144	4,121	2,360	5,085	1,846	2,527	1,846	2,452	1,795	2,243	34,835	2,903
1914.....	2,178	2,173	2,287	1,741	2,475	2,768	2,263	1,677	1,369	2,850	1,336	1,357	24,474	2,040
1915.....	1,670	814	1,685	1,112	1,177	753	1,276	981	1,079	699	1,350	895	13,501	1,125
1916.....	891	833	795	1,502	1,451	2,621	1,965	1,265	1,933	3,678	4,047	3,253	24,234	2,020

KENTUCKY AND TENNESSEE.

GENERAL STATEMENT.

In the annals of the petroleum industry of Kentucky the year 1916 must be recorded as the beginning of a new epoch of expansion, based on the solid foundation of increased production from new territory. Inclusive of 677 barrels of oil produced in Tennessee, the output of petroleum in Kentucky in 1916 was 1,203,246 barrels. This quantity was greater by 765,972 barrels, or 175 per cent, than the output in 1915, and was greater than the output in any other year except 1905 and 1906, in which years, however, the output was only a few per cent in excess of that in 1916.

The average price received at the wells for all grades of Kentucky and Tennessee oil in 1916 was $1.82 a barrel and the total market value of the output was $2,189,812, inclusive of $1,317 credited to Tennessee.

The total market value of the output in 1916 exceeded that of the output in any other year, and the average price per barrel was higher than in any other year except 1892.

DEVELOPMENT.

Drilling activity in Kentucky in 1916 resulted in the completion of 1,074 wells, of which 878 were credited with an average initial yield of 31 barrels of oil each, 17 were gas wells, and 179, an average of 1 in every 6, were failures.

The interest taken by oil producers in the prospects and possibilities of production in Kentucky is indicated by the fact that drilling and wildcatting included 21 counties in its scope in 1916, as compared with only 9 in 1915, and that the number of wells completed in 1916 was more than 11 times the number completed in 1915, an abnormal year, and more than 6 times the number completed in 1914.

The greater proportion of the activity in 1916 was in Estill County, which is credited with 773 new wells, 681 of which produced an average of 33 barrels of oil each the first day of productive life, 6 were gassers, and the remaining 86 were barren. More specifically the location of this activity was the Irvine district, which was rejuvenated as a source of petroleum in 1915 as a consequence of the successful completion of wildcat tests northeast of the old pool. The attractive features of this district were the shallow depth, averaging less than 900 feet, at which oil was obtained, the relatively large initial capacities of the wells, and the tendency of the wells to maintain for several months the rate of production indicated by their

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initial flows. The active development in 1916 was restricted chiefly to line drilling and advance work seeking to determine the exterior limits of the field. As a consequence of the extensions proved in 1916, the field as defined at the end of the year covered a roughly crescentic area from 2 to 3 miles wide trending northeastward from the north end of the old development a mile southeast of Irvine into southern Powell County, thence eastward to a point about 6 miles west of Torrent, a station on the Louisville & Nashville Railroad, and about 4 miles west of the Campton field in Wolfe County, the total length being about 10 miles. Between the east end of the Irvine field and Torrent a few scattered wells had been completed before the end of 1916, but the results obtained were inconclusive as to the further extent of the field in this direction. South of the Irvine district proper a subsidiary pool of small extent was opened near the mouth of Furnace Branch of Miller Creek. More important, however, was the opening of the Station Camp or Wagersville pool in the southern part of Estill County, about 5 miles south of Irvine, where wells less than 300 feet deep were credited with initial flows as high as 100 barrels.

The oil in this field is of paraffin base, is dark brown in color, and ranges in gravity between 34° and 37° Baumé. It is classed as Somerset grade by the purchasing agencies. The reservoir rock in the Irvine district ranges in thickness between 15 and 40 feet and is a member of the "Corniferous" limestone of the Devonian system.

Marketing facilities, which early in 1916 consisted of a gravity pipe line to loading racks along the Louisville & Nashville Railroad at Ravenna, near Irvine, were increased in June by the completion of a 3-inch extension of the Cumberland Pipe Line Co.'s line from Campton to Ravenna and in August by the completion, also by the Cumberland Pipe Line Co.; of a supplemental 4-inch line from Campton to Fitchburg, in the east end of the Irvine district. A 3-inch extension of this latter line from Fitchburg, traversing the western part of the Irvine district and extending southward into the Station Camp pool, was completed in December.

The success of operations in Estill County inspired a great amount of wildcat drilling in adjacent counties. To the north, in Powell County, efforts to develop a pool near Clay City were disappointing. To the east, in the western part of Wolfe County and the northern part of Lee County, wildcat tests yielded encouraging but inconclusive results. To the south, in Jackson County, three tests near Drip Rock in quest of a southern extension of the Station Camp pool were barren. To the west, in Madison County, two gas wells and one oil well of small capacity were completed near Big Hill. Some distance to the southwest, in Rockcastle County unsuccessful tests were drilled near Mount Vernon, Brodhead, and Gum Sulphur, though the tests near Mount Vernon yielded encouraging showings of oil.

Though overshadowed by the larger scale operations in Estill County, significant progress was made in 1916 in the development of the Scottsville-Petroleum district in Allen County, near the Tennessee boundary, in the west-central part of Kentucky. Of 131 wells drilled in this district during the year, 99 were credited with an average initial yield of 39 barrels of oil each, 4 were gassers, and 28 were failures. As a consequence of this activity the potential capacity

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of the district is estimated to have been increased from 600 to possibly 2,000 barrels of oil a day. During the year the Wildwood pool, southeast of Scottsville, was extended to the east, and evidence of the existence of a new pool about 3 miles northeast of Scottsville was confirmed.

Evidence of the existence of other pools in this district was furnished late in 1916 by the discovery of oil in considerable quantities in tests on the Guy farm near Pope, 7 miles west of Scottsville, and of gas in a test on the Reynolds farm near Halifax, about the same distance north of Scottsville.

Shipments of oil from the Scottsville-Petroleum district, which are made exclusively by tank car, to Nashville, Tenn., and Lawrenceville, Ill., were considerably in excess of shipments in any other year.

Northeast of the Allen County field a revival of activity in the pioneer oil field of Kentucky near Glasgow, Barren County, resulted in the completion of 5 productive oil wells and 1 dry hole. Farther to the east, in Metcalfe County, the nucleus of a new shallow-sand pool was provided by the completion of 2 oil wells of small capacity on the Gaddie farm, near Beachville. In Warren County encouraging showings of both oil and gas were found in tests near Bowling Green and in Grayson County a small gas well was completed in December near Anneta.

Drilling in the proved districts of Wayne, Morgan, Floyd, Knott, Wolfe, Bath, Rowan, and Lawrence counties, though more active in 1916 than in 1915, resulted in no consequential extensions of territory. In Bath County wildcat drilling near Olympia, 15 miles northwest of the Ragland pool, resulted in July in the completion on the Mays farm of an oil well credited with an initial capacity of 30 barrels. Two gas wells of small capacity were subsequently completed in this new field. Renewed activity in Whitley County on the Tennessee border, in eastern Kentucky, resulted in the completion in December, as a 10-barrel oil well, of a test well drilled at the head of Lonesome Creek in the long neglected Williamsburg district.

TENNESSEE.

The desultory search for petroleum in Tennessee that has been under way since the flooding and abandonment of the Spurrier and Riverton field in Pickett County in 1906 was rewarded in 1916 by the discovery of oil in Scott County in sufficient quantities to restore Tennessee to its former place among the contributors to the petroleum supply of the United States. The quantity of petroleum marketed from Tennessee sources in 1916 was 677 barrels, having a market value of $1,317. This output was obtained wholly from two wells, one completed in August on the Pemberton farm, the other in November on the Todd farm, near Glenmary, a station on the Cincinnati, New Orleans & Texas Pacific Railway, about 15 miles south of Oneida, the county seat. The initial yield of the discovery well was estimated at 25 barrels, and that of the Todd well at 20 barrels. The oil is dark green in color, is of paraffin base, and has a gravity of 38.4 Baumé. It is obtained from an 8-foot layer in the Newman limestone of the Mississippian (lower Carboniferous) series, which was entered in the discovery well at a depth of 1,232 feet. Additional development was under way at the end of 1916.

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In the Oneida district, which seemed to offer so much of promise in 1915, the results of drilling in 1916 were wholly disappointing and the area was practically abandoned.

MARKETED PRODUCTION.

Petroleum marketed in Kentucky, 1912–1916, in barrels.

Month.	1912	1913	1914	1915	1916
January	38,425	42,074	46,930	34,968	33,751
February	37,723	36,843	44,545	35,707	40,657
March	40,923	39,391	53,860	39,562	51,323
April	37,375	39,036	50,465	40,015	65,545
May	44,967	42,932	44,903	39,323	86,102
June	40,311	39,285	44,361	37,070	81,409
July	44,997	48,211	42,630	35,905	94,001
August	40,866	49,908	26,758	37,531	134,432
September	39,146	52,538	21,177	34,929	143,093
October	38,484	46,301	51,625	33,564	162,060
November	40,000	44,137	36,900	34,702	157,655
December	41,151	43,912	38,287	34,068	153,188
	484,368	524,568	502,441	437,274	a1,203,246

a Includes 677 barrels from Tennessee.

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Pipe-line runs in Kentucky in 1915 and 1916, in barrels.

1915.

Month ending—	Wayne County.					Wolfe County.				Irvine.	Bussey-ville.	Beaver Creek.	Cannel City.	Ragland.	Wil-liams-burg.	Total.
	Cooper.	Griffin (Denny).	Parm-leysville.	Steuben-ville.	Total.	Campton.	Still-water.	Page Hollow.	Total.							
Jan. 30	5,389	6,666	2,854	4,732	19,641	2,502	642	.....	3,144	.....	2,018	967	4,416	3,032	149	33,367
Feb. 27	5,520	7,201	3,021	5,292	21,034	2,118	457	.....	2,575	.....	1,685	759	3,122	3,955	149	33,279
Mar. 27	4,901	7,110	2,283	7,007	21,301	1,097	766	.....	1,863	.....	2,341	1,985	2,746	3,314	149	33,699
May 1	6,474	8,511	4,304	10,944	30,233	2,758	917	.....	3,675	.....	2,539	1,040	4,295	3,731	149	45,662
May 29	4,782	6,046	3,020	7,306	21,154	1,711	337	.....	2,048	.....	2,264	1,190	2,056	3,722	.....	32,434
June 26	4,578	5,470	2,990	6,490	19,528	2,174	1,095	.....	3,269	.....	1,986	928	2,515	2,977	149	31,352
July 31	5,753	6,705	4,010	7,194	23,662	2,253	901	.....	3,154	.....	3,213	1,060	4,278	4,624	.....	39,991
Aug. 28	4,425	4,915	3,050	5,003	17,393	1,975	920	.....	2,895	.....	2,299	1,199	1,791	2,772	.....	28,349
Oct. 2	5,530	6,262	3,975	6,697	22,464	2,060	1,000	.....	3,060	.....	2,220	967	2,701	4,264	149	36,525
Oct. 30	4,457	5,042	3,200	5,104	17,803	876	767	393	2,036	.....	2,241	895	1,913	2,611	149	27,648
Nov. 27	4,093	4,263	3,262	4,794	16,412	2,015	747	.....	2,762	.....	2,107	799	2,731	1,588	.....	26,399
Jan. 1, 1916	5,698	5,234	3,530	6,468	20,930	2,704	979	.....	3,683	727	2,579	682	3,386	2,865	149	35,001
	61,600	73,425	39,499	77,031	251,555	24,243	9,528	393	34,164	727	28,192	12,471	35,950	39,455	1,192	403,706

1916.

Month ending—	Wayne County.					Wolfe County.				Estill County.				Bussey-ville.	Beaver Creek.	Cannel City.	Ragland.	Lewis.	Wil-liams-burg.	Total.
	Cooper.	Griffin (Denny).	Parm-leysville.	Steuben-ville.	Total.	Campton.	Still-water.	Page Hollow.	Total.	Ravenna-Irvine.	Fitch-burg.	Wagers-ville.	Total.							
Jan. 29	3,144	3,823	3,197	5,813	15,977	987	760	301	2,048	2,121	.....	.....	2,121	1,420	854	1,715	2,972	.....	.....	27,107
Feb. 26	4,267	3,711	3,087	4,782	15,847	1,485	639	.....	2,124	8,725	.....	.....	8,725	2,213	836	1,882	2,554	.....	149	34,330
Apr. 1	4,164	3,227	3,103	5,159	15,653	714	785	1,137	2,636	15,000	.....	.....	15,000	3,278	838	232	2,631	1,919	149	42,336
Apr. 29	4,201	3,592	2,941	4,990	15,724	2,076	684	.....	2,760	32,344	.....	.....	32,344	2,454	1,079	.....	3,324	1,141	.....	58,826
May 27	4,113	3,323	3,001	5,339	15,776	1,211	807	.....	2,018	48,250	.....	.....	48,250	1,682	887	.....	3,324	1,318	.....	73,255
July 1	5,147	4,697	4,055	5,393	19,292	2,646	608	.....	3,254	57,846	.....	.....	57,846	3,865	926	.....	2,798	2,338	.....	90,319
July 29	4,098	2,561	3,071	4,290	14,020	1,386	322	.....	1,708	55,721	.....	.....	55,721	2,886	378	.....	2,807	1,735	.....	79,265
Sept. 2	5,134	4,277	4,070	4,871	18,352	2,392	778	.....	3,170	102,364	1,825	.....	104,189	4,137	891	.....	3,617	2,297	.....	136,653
Sept. 30	4,436	3,076	2,772	3,882	14,166	457	1,158	855	2,470	89,457	11,111	.....	100,568	2,390	459	.....	2,119	1,406	.....	123,578
Oct. 28	3,697	3,204	2,802	3,645	13,348	1,226	821	.....	2,047	103,471	9,666	.....	113,137	4,190	1,141	.....	2,145	1,573	.....	137,581
Dec. 2	3,775	4,287	3,601	4,803	16,466	2,556	1,069	.....	3,625	125,800	21,870	213	147,883	3,649	992	.....	3,365	2,148	.....	178,128
Dec. 30	3,190	2,905	2,871	3,095	12,061	935	921	154	2,010	94,304	18,251	2,012	114,567	4,212	492	.....	2,695	1,338	.....	137,375
	49,366	42,683	38,571	56,062	186,682	18,071	9,352	2,447	29,870	735,403	62,723	2,225	800,351	36,376	9,773	3,829	34,351	17,213	298	1,118,743

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SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on page 706, which are obtained from reports received directly from the oil producers.

Wells completed in Kentucky, 1912–1916.

County.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Allen	.....	7	16	1	99	.....	1	1	1	28	.....	8	19	2	131
Barren	.....	3	.....	.....	5	.....	3	.....	.....	1	.....	6	.....	.....	6
Bath	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....	.....	.....	.....	3
Cumberland	1	.....	.....	.....	.....	.....	1	.....	.....	.....	1	2	.....	.....	.....
Daviess	.....	.....	2	.....	.....	.....	.....	1	3	.....	.....	.....	3	3	.....
Edmonson	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....
Estill	.....	.....	3	2	681	.....	.....	.....	.....	86	.....	.....	3	2	773
Floyd	4	.....	.....	.....	.....	.....	1	1	.....	2	4	1	1	.....	2
Grayson	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Jackson	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	3
Johnson	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....
Lawrence	20	9	9	10	20	12	1	.....	2	1	33	11	10	12	21
Lee	.....	.....	.....	.....	2	.....	.....	.....	.....	2	.....	.....	.....	.....	4
Madison	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
Martin	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Metcalfe	.....	.....	.....	.....	2	.....	.....	.....	.....	2	.....	.....	.....	.....	4
Montgomery	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	2
Morgan	.....	32	10	1	2	.....	13	5	1	5	.....	48	15	2	7
Ohio	.....	.....	4	.....	.....	.....	.....	4	.....	.....	.....	.....	8	.....	.....
Powell	.....	.....	.....	.....	21	.....	.....	.....	.....	10	.....	.....	.....	.....	32
Rockcastle	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	.....	.....	.....	.....	8
Simpson	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Warren	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
Wayne	75	67	68	31	29	44	31	34	27	27	119	98	102	58	56
Webster	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....
Whitley	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....	.....	.....	.....	2
Wolfe	9	12	6	10	12	2	10	4	1	1	11	22	10	11	13
Other	3	3	.....	.....	.....	3	8	5	.....	.....	10	14	6	.....	.....
	112	133	119	56	878	61	69	55	36	179	178	210	178	92	1,074

[a] Including gas wells.

Oil wells and dry holes drilled in Kentucky in 1916.

County.	January.		February.		March.		April.		May.		June.		July	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Allen	2	.....	2	.....	5	2	6	.....	8	4	5	.....	20	8
Barren	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....
Bath	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....
Estill	44	4	19	4	18	2	24	2	30	5	34	1	74	3
Floyd	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....
Jackson	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Lawrence	1	.....	1	.....	2	.....	.....	.....	6	.....	.....	.....	2	.....
Lee	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Madison	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....
Martin	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....
Metcalfe	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Montgomery	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
Morgan	.....	1	.....	2	.....	1	.....	.....	.....	.....	.....	.....	.....	.....
Powell	.....	1	.....	.....	.....	.....	.....	1	3	.....	3	.....	1	.....
Rockcastle	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Warren	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....
Wayne	1	1	2	1	3	3	5	2	2	5	3	2	6	2
Whitley	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Wolfe	.....	.....	1	.....	1	.....	.....	1	1	.....	1	.....	.....	.....
	48	7	25	7	30	8	35	6	51	15	48	3	104	15

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Oil wells and dry holes drilled in Kentucky in 1916—Continued.

County.	August.		September.		October.		November.		December.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Allen	10	2	14	10	10	.....	9	1	8	1	99	28
Barren	.....	.....	1	1	.....	.....	3	.....	.....	.....	5	1
Bath	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	1
Estill	76	16	91	11	108	24	78	4	85	10	681	86
Floyd	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	2
Jackson	.....	.....	.....	1	.....	2	.....	.....	.....	.....	.....	3
Lawrence	2	.....	2	.....	1	.....	2	1	1	.....	20	1
Lee	.....	.....	.....	.....	1	1	.....	.....	1	1	2	2
Madison	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....
Martin	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....
Metcalfe	1	.....	.....	.....	.....	1	1	.....	.....	1	2	2
Montgomery	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
Morgan	1	1	.....	.....	.....	.....	.....	.....	1	.....	2	5
Powell	2	1	9	6	.....	1	1	.....	2	.....	21	10
Rockcastle	.....	2	.....	.....	.....	1	.....	1	.....	3	.....	7
Warren	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....
Wayne	1	3	4	2	2	.....	.....	3	.....	3	29	27
Whitley	.....	.....	.....	.....	.....	.....	.....	1	1	.....	1	1
Wolfe	1	.....	.....	.....	1	.....	2	.....	4	.....	12	1
	94	25	121	31	123	30	96	12	103	20	878	179

Wells completed in Kentucky, 1912–1916.

Month.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
January	10	6	11	1	48	3	4	5	3	7	13	11	16	4	58
February	3	15	12	3	25	1	7	7	4	7	6	23	19	7	32
March	14	4	11	4	30	5	4	2	1	8	19	9	13	5	38
April	10	11	14	5	35	1	9	7	.....	6	11	21	21	5	41
May	12	12	8	10	51	3	4	4	9	15	16	17	12	19	66
June	8	9	14	5	48	7	7	8	6	3	15	16	22	11	52
July	6	11	12	4	104	2	6	5	2	15	8	18	18	6	120
August	11	10	14	3	94	7	5	6	1	25	18	17	20	4	122
September	18	19	8	2	121	17	7	5	1	31	37	26	14	3	156
October	6	11	3	5	123	4	2	3	3	30	10	13	7	8	153
November	9	10	8	6	96	7	4	2	4	12	16	14	10	10	110
December	5	15	4	8	103	4	10	1	2	20	9	25	6	10	126
	112	133	119	56	878	61	69	55	36	179	178	210	178	92	1,074

[a] Including gas wells.

Initial daily production of new wells completed in Kentucky in 1916, in barrels.

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Allen	27	80	205	290	295	150	579	580	350	260	601	460	3,877
Barren	.....	.....	.....	.....	.....	10	.....	.....	5	.....	7	.....	22
Bath	.....	.....	.....	.....	.....	.....	30	.....	.....	.....	.....	.....	30
Estill	625	419	542	982	773	1,875	2,902	2,995	3,001	3,039	2,499	2,929	22,581
Lawrence	3	1	10	.....	35	.....	10	8	7	5	10	5	94
Lee	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....	25	35
Madison	.....	.....	.....	.....	.....	5	.....	.....	.....	.....	.....	.....	5
Martin	.....	.....	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	10
Metcalfe	.....	.....	.....	.....	.....	.....	.....	7	.....	.....	5	.....	12
Morgan	.....	.....	.....	.....	.....	.....	.....	5	.....	.....	.....	25	30
Powell	.....	.....	.....	.....	4	55	125	55	41	.....	75	10	365
Warren	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	1
Wayne	5	12	7	9	11	15	32	5	8	2	.....	.....	106
Whitley	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	10
Wolfe	.....	5	5	.....	4	4	.....	4	.....	15	30	65	132
	660	517	779	1,281	1,123	2,114	3,678	3,659	3,412	3,331	3,227	3,529	27,310

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Total and average initial daily production of new wells in Kentucky, 1912–1916, by counties, in barrels.

County.	Total initial production.					Average per well.				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Allen	.....	114	335	50	3,877	.....	16.3	20.9	50.0	39.2
Barren	.....	14	.....	.....	22	.....	4.7	.....	.....	4.4
Bath	.....	.....	.....	.....	30	.....	.....	.....	.....	30.0
Cumberland	3	.....	.....	.....	.....	3.0	.....	.....	.....	.....
Daviess	.....	.....	10	.....	.....	.....	.....	5.0	.....	.....
Edmonson	.....	.....	.....	10	.....	.....	.....	.....	10.0	.....
Estill	.....	.....	23	125	22,581	.....	.....	7.7	62.5	33.2
Floyd	35	.....	.....	.....	.....	8.9	.....	.....	.....	.....
Johnson	.....	.....	10	.....	.....	.....	.....	10.0	.....	.....
Lawrence	148	65	69	78	94	7.4	7.2	7.7	7.8	4.7
Lee	.....	.....	.....	.....	35	.....	.....	.....	.....	17.5
Madison	.....	.....	.....	.....	5	.....	.....	.....	.....	5.0
Martin	.....	.....	.....	.....	10	.....	.....	.....	.....	10.0
Metcalf	.....	.....	.....	.....	12	.....	.....	.....	.....	6.0
Morgan	.....	967	96	3	30	.....	30.2	9.6	3.0	15.0
Ohio	.....	.....	150	.....	.....	.....	.....	37.5	.....	.....
Powell	.....	.....	.....	.....	365	.....	.....	.....	.....	17.4
Warren	.....	.....	.....	.....	1	.....	.....	.....	.....	1.0
Wayne	1,481	723	843	408	106	19.7	10.8	12.4	13.2	3.7
Whitley	.....	.....	.....	.....	10	.....	.....	.....	.....	10.0
Wolfe	196	107	32	54	132	21.8	8.9	5.3	5.4	11.0
Other	80	225	.....	.....	.....	26.7	75.0	.....	.....	.....
	1,943	2,215	1,568	728	27,310	17.3	16.7	13.2	13.0	31.1

Total initial daily production of new wells in Kentucky, 1912–1916, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1912	122	35	341	255	216	255	112	213	121	128	75	70	1,943	162
1913	43	325	105	501	93	138	221	166	192	124	109	198	2,215	185
1914	140	238	148	267	94	122	155	165	120	28	66	25	1,568	131
1915	1	122	33	119	128	24	14	25	6	53	30	173	728	61
1916	660	517	779	1,281	1,123	2,114	3,678	3,659	3,412	3,331	3,227	3,529	27,310	2,276

Wells completed in Tennessee, in 1915 and 1916.

County.	Oil.		Dry.		Total completed.[a]	
	1915	1916	1915	1916	1915	1916
Fentress	.....	.....	1	1	1	1
Scott	4	2	6	6	11	8
	4	2	7	7	12	9

[a] Including gas wells.

Oil wells and dry holes drilled in Tennessee in 1916.

County.	January.		February.		March.		April.		May.		June.		July.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Fentress	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Scott	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5
	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5

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Oil wells and dry holes drilled in Tennessee in 1916—Continued.

County.	August.		September.		October.		November.		December.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Fentress												1
Scott			1				1				2	6
			1				1				2	7

Wells completed in Tennessee in 1915 and 1916.

Month.	Oil.		Dry.		Total completed.[a]	
	1915	1916	1915	1916	1915	1916
January				2		2
February						
March						
April						
May						
June						
July	3		1	5	4	5
August						
September		1	1		1	1
October	1		1		3	
November		1	2		2	1
December			2		2	
	4	2	7	7	12	9

[a] Including gas wells.

Initial daily production of new wells completed in Tennessee in 1916, in barrels.

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Fentress													
Scott									25		20		45
									25		20		45

Total and average initial daily production of new wells in Tennessee in 1915 and 1916, in barrels.

County.	Total initial production.		Average per well.	
	1915	1916	1915	1916
Fentress				
Scott	250	45	62.5	22.5
	250	45	62.5	22.5

Total initial daily production of new wells in Tennessee in 1915 and 1916, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1915							150			100			250	21
1916									25		20		45	4

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OHIO.[1]

GENERAL STATEMENT.

Following the precedent of recent years, broken in the last decade only in 1912, the marketed production of petroleum in Ohio in 1916 registered a decline. The combined output of all grades of petroleum from Ohio sources in 1916 was 7,744,511 barrels, a quantity less by 80,815 barrels, or 1 per cent, than the output of 1915. Of this output the Lima or northwestern division contributed 40 per cent and the southeast-central division 60 per cent. The loss in production is assignable wholly to the Lima division, the output of which was 257,866 barrels, or 7.6 per cent, less than in 1915. That the percentage decline for the entire State was no greater than that recorded was due to a gain of 177,051 barrels, or 4 per cent, in the output of the southeast-central division.

The average price at the wells for all grades of oil produced in Ohio in 1916 was $2.09 a barrel, and the market value of the entire output was $16,154,940, these figures showing a gain of 80 cents in average unit price and of $6,093,447, or 61 per cent, in total market value compared with those for 1915. Of the total market value, 30 per cent is credited to the Lima division and the remaining 70 per cent to the southeast-central division. The average price received for the product of the Lima division was $1.57 a barrel and for that of the southeast-central division was $2.44 a barrel, these prices being respectively 60 cents and 91 cents higher than the averages in 1915. Never before in the history of the Lima division has the average yearly price for its product reached the height attained in 1916 and not since 1877 has the average yearly price of oil in the southeast-central exceeded $2 a barrel.

DEVELOPMENT.

As might be expected from the foregoing statement of market conditions, the record of drilling activity in Ohio showed a decided increase in 1916 over 1915. Twenty-eight counties in the southeast-central division and 14 in the Lima division shared in this activity, compared with 26 and 12, respectively, in 1915. A total of 2,553 wells were completed, inclusive of 1,543 oil wells credited with an average initial yield of 8 barrels each, 413 gas wells, and 597 dry holes, the ratio of failures to total completions being roughly as 3 to 13, the same as in 1915.

Southeast-central division.—In the many productive districts of central and eastern Ohio 1,854 wells were completed in 1916, of which 927, or 50 per cent, produced an average of 12 barrels of oil each the first 24 hours after completion, 402, or 22 per cent, were gas wells, and 525, or 28 per cent, were barren. Although the total number of wells completed in this division in 1916 was 56 less than in 1915, the loss was entirely in the number of gas wells drilled, as the number of oil wells completed was greater by 250 and the number of dry holes greater by 53 than in 1915.

[1] Of the two areas of oil production in Ohio only the southeast-central area belongs geographically in the Appalachian oil field, the Lima area, in northwestern Ohio, forming a part of the so-called Lima-Indiana oil field. In accordance with the custom in previous reports, however, the statistics for both areas are given here, to make the statement for Ohio cover the whole State. The Lima statistics are, of course, omitted from the tables covering the Appalachian field as a whole.

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The gain of 4 per cent in the output of petroleum in this division in 1916 was a consequence in part of the increased number of oil wells drilled but principally of the completion during the early months of the year of a number of oil wells of relatively large capacity in the Union Furnace district, Hocking County.

In the so-called "shallow-sand" districts of southeastern Ohio, where production is obtained from strata of the Carboniferous system, Washington County maintained its position of leader in drilling activity, having 326 new oil wells to its credit at the end of the year. Although minor extensions were made to a number of the old pools in the shallow-sand area, no new territory of consequence was opened.

In Knox Township, Jefferson County, new production was obtained in the Berea sand on the Sutton farm, and in Carroll County the completion late in December as a 25-barrel oil well of a wildcat test in sec. 16, Union Township, was interpreted as indicating a pool in the Berea sand in a new locality about 6 miles north of the old Scio pool in Harrison County and about 20 miles south of the Homeworth pool in Columbiana County.

In the "deep-sand" area to the west of the "shallow-sand" fields, where production is obtained in the "Clinton" sand at an average depth of 3,000 feet, interest was divided mainly between Hocking and Perry counties, both of which furnished a number of creditable wells in the course of the year and both of which were favored with encouraging though slight extensions of productive territory. At the southern end of the "Clinton" sand field continued efforts to develop a pool near Creola, Swan Township, Vinton County, met with fair success as to natural gas. A number of gas wells of large capacity were completed during the year in this county in Jackson and Richland townships southwest of Creola. Farther north in Muskingum County, drilling in sec. 2, Licking Township, resulted in the development of a promising "Clinton" sand pool near Nashport, and still farther in this direction fair success resulted from additional efforts to develop the "Clinton" sand pool in Holmes and Knox counties that was discovered near Brinkhaven in 1915.

Impetus to drilling in Wayne County was furnished in June by the completion of a 25-barrel oil well on the Albright farm, a mile east of the former limits of the Wooster pool.

At the north end of the central Ohio field a few scattered oil wells of small capacity were found in the course of developments in the Cleveland gas field. Most of the activity in this field in 1916 was in territory west and southwest of Cleveland in Rockport, Dover, and Middleburg townships, Cuyahoga County.

In northeastern Ohio further drilling in the vicinity of the small oil well completed in 1915, on the Drury farm, near Saybrook, Ashtabula County, resulted in the development of additional production of gas but not of oil.

Northwestern division.—In the old Lima field the results of drilling in 1915 included 616 oil wells credited with an average initial output of 15 barrels each, 11 gas wells, and 72 (an average of about 1 in 10) dry holes.

Field activity in the division was distributed over 18 counties, Wood County leading in the number of new wells completed and in the total volume of initial production, but Seneca County leading in the average initial output per well. Owing to the fact that the

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productive territory in this division has been under active development for about 30 years, field activity has come to be restricted chiefly to the intensive drilling of long-neglected properties from which the flush production was recovered years ago. Although the rewards of drilling in areas of this type are not great, they are relatively certain and occasionally include the discovery of prolific tracts overlooked in the earlier development. Examples of this kind were furnished in 1916 by well No. 12, on the J. Priest farm, in sec. 28, Liberty Township, Wood county, completed in April, with an estimated initial capacity of 200 barrels, and by well No. 6, on the B. F. Pollock farm, in sec. 1, York Township, Van Wert County, completed in May and credited with an initial flow of 163 barrels of oil.

Wildcat drilling in 1916 resulted in the opening of a promising extension to developed territory near McComb, Portage Township, Hancock County, in April, and in the discovery in May of what was thought might develop into a small pool on the Truman Zeis farm, in sec. 34, Seneca Township, Seneca County, about 5 miles southwest of the prolific Orphans' Home pool, near Tiffin.

MARKETED PRODUCTION.

Petroleum marketed in Ohio in 1912–1916, in barrels.

Month.	Lima.				
	1912	1913	1914	1915	1916
January	254,382	336,665	341,162	271,437	247,491
February	215,764	275,831	229,310	274,450	252,535
March	316,946	279,117	343,414	311,095	287,652
April	366,846	349,204	338,745	313,775	271,492
May	380,394	333,866	326,256	283,022	287,382
June	354,165	317,476	331,000	295,378	277,206
July	365,227	327,556	337,431	291,978	265,272
August	358,260	319,486	319,529	275,442	269,449
September	322,245	319,443	312,202	276,998	250,038
October	253,881	332,992	314,526	278,632	260,332
November	313,361	296,090	275,469	261,197	248,223
December	[a] 321,426	329,317	254,983	260,429	218,895
	[a] 3,955,897	3,817,043	3,727,087	3,393,833	3,135,967

Month.	Southeastern Ohio.				
	1912	1913	1914	1915	1916
January	333,489	407,538	444,426	382,236	355,553
February	356,983	364,307	363,537	361,100	344,767
March	413,795	324,699	464,675	398,130	385,306
April	440,834	456,072	448,909	385,127	371,192
May	453,807	420,757	436,266	362,097	401,866
June	416,396	414,698	428,753	377,345	422,673
July	439,748	424,588	456,139	366,426	389,532
August	460,361	410,459	195,617	357,799	409,467
September	410,131	425,023	299,372	353,556	376,239
October	437,877	456,364	507,031	363,534	388,561
November	397,129	406,018	373,117	342,700	386,229
December	422,560	453,902	391,423	380,843	377,159
	5,013,110	4,964,425	4,809,265	4,431,493	4,608,544

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Petroleum marketed in Ohio in 1912–1916, in barrels—Continued.

Month.	Total.				
	1912	1913	1914	1915	1916
January	587,871	744,203	785,588	653,673	603,044
February	602,747	640,138	592,847	635,550	597,302
March	760,741	603,816	808,089	709,525	672,958
April	807,680	805,276	787,654	699,202	642,684
May	834,201	754,623	765,522	645,119	689,248
June	770,561	732,174	759,813	672,723	699,879
July	804,975	752,144	793,570	658,404	651,804
August	818,621	729,945	515,146	633,241	678,916
September	732,376	744,466	611,574	630,554	626,277
October	791,758	789,356	821,557	642,166	648,803
November	710,490	702,108	648,586	603,897	634,452
December	746,986	783,219	646,406	641,272	596,054
	8,969,007	8,781,468	8,536,352	7,825,326	7,744,511

[a] Includes production of Michigan.

Quantity, value, and average price per barrel of petroleum produced in Ohio, 1907–1916.

Year.	Lima.			Southeastern Ohio.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1907	7,993,057	$7,425,480	$0.929	4,214,391	$7,344,408	$1.742	12,207,448	$14,769,888	$1.209
1908	6,748,676	6,861,885	1.016	4,110,121	7,316,617	1.780	10,858,797	14,178,502	1.305
1909	5,915,357	5,451,497	.921	4,717,436	7,773,880	1.647	10,632,793	13,225,377	1.243
1910	5,094,136	4,181,629	.821	4,822,234	6,469,939	1.341	9,916,370	10,651,568	1.074
1911	4,535,875	3,888,119	.857	4,281,237	5,591,423	1.306	8,817,112	9,479,542	1.075
1912	[a]3,955,997	3,908,809	.988	5,013,110	8,177,189	1.628	8,969,007	12,085,998	1.347
1913	3,817,043	5,306,842	1.391	4,964,425	12,229,610	2.463	8,781,468	17,538,452	1.997
1914	3,727,087	4,435,314	1.190	4,809,265	8,937,415	1.858	8,536,352	13,372,729	1.567
1915	3,393,833	3,300,833	.973	4,431,493	6,760,660	1.526	7,825,326	10,061,493	1.286
1916	3,135,967	4,909,704	1.566	4,608,544	11,245,236	2.440	7,744,511	16,154,940	2.086

[a] Includes production of Michigan.

SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on page 706, which are obtained from reports received directly from the oil producers.

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Wells completed in central and southeastern Ohio, 1912–1916.

County.	Oil.					Dry.					Total completed.a				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Ashland	.....	1	2	1	1	34	21	15	27	22	131	118	88	88	57
Ashtabula	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1
Athens	3	15	7	16	16	5	12	8	4	4	10	28	19	21	21
Belmont	9	21	15	12	14	3	29	24	13	9	13	58	55	34	29
Carroll	5	21	29	24	19	5	22	7	13	9	11	44	38	41	29
Columbiana	4	28	58	37	16	13	18	12	23	18	17	47	72	64	46
Coshocton	9	15	13	2	4	1	.....	5	4	3	10	18	18	7	8
Cuyahoga	4	.....	7	13	19	4	1	35	68	29	19	1	384	515	169
Erie	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	2	.....	.....
Fairfield	25	44	25	12	13	19	28	13	7	9	60	91	44	23	30
Guernsey	.....	11	.....	.....	.....	.....	22	2	.....	.....	.....	33	2	.....	.....
Harrison	11	19	17	12	13	7	10	7	2	9	23	29	25	16	25
Hocking	74	178	97	71	95	12	30	48	17	27	129	137	181	105	127
Holmes	.....	1	.....	.....	6	.....	2	.....	3	3	.....	3	.....	3	10
Jackson	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1
Jefferson	30	60	33	16	39	19	22	16	14	22	57	83	58	32	67
Knox	.....	1	.....	1	5	12	8	1	5	.....	53	24	1	13	9
Lake	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....
Licking	37	38	16	16	18	35	26	18	9	13	109	144	92	68	74
Lorain	1	1	.....	.....	.....	13	5	3	3	2	19	8	4	5	5
Madison	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....	.....	.....	.....
Medina	.....	.....	.....	4	3	5	8	7	11	8	23	28	29	28	24
Meigs	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....
Monroe	70	100	51	34	60	24	31	35	17	17	102	137	93	53	82
Morgan	118	142	91	64	35	78	50	45	21	20	196	192	136	85	56
Muskingum	18	21	15	19	71	11	8	5	7	18	30	33	23	27	92
Noble	19	62	45	36	22	21	37	40	25	31	43	101	90	67	57
Perry	188	172	112	41	104	23	40	34	12	18	219	220	151	55	123
Richland	.....	.....	.....	.....	.....	4	8	16	10	2	21	31	33	32	11
Summit	.....	.....	.....	.....	.....	2	2	.....	.....	.....	3	2	.....	.....	.....
Tuscarawas	.....	.....	.....	.....	2	2	1	.....	.....	2	2	1	.....	.....	4
Vinton	1	.....	.....	6	25	1	.....	2	14	29	5	.....	6	41	110
Washington	206	370	221	240	326	94	151	104	111	183	303	533	333	360	525
Wayne	14	25	9	.....	1	12	11	15	31	16	47	47	61	126	62
	846	1,246	863	677	927	460	603	517	472	525	1,717	2,191	2,044	1,910	1,85.

a Including gas wells.

Oil wells and dry holes drilled in central and southeastern Ohio in 1916.

County.	January.		February.		March.		April.		May.		June.		July.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Ashland	1	1	.....	2	.....	.....	.....	.....	.....	1	.....	.....	.....	3
Ashtabula	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....
Athens	.....	.....	.....	.....	.....	.....	.....	.....	6	1	.....	.....	4	2
Belmont	4	1	1	.....	1	.....	.....	1	1	.....	1	1	1	1
Carroll	1	1	3	.....	1	1	3	.....	1	.....	2	.....	1	2
Columbiana	4	4	2	1	1	.....	2	1	2	2	.....	2	2	4
Coshocton	.....	.....	1	.....	2	.....	.....	.....	.....	.....	.....	.....	1	.....
Cuyahoga	8	4	1	4	.....	5	3	8	1	1	1	2	2	1
Fairfield	1	1	.....	.....	.....	.....	2	2	1	.....	3	1	1	.....
Harrison	2	.....	2	1	2	.....	1	1	1	2	.....	1	1	.....
Hocking	5	.....	9	2	2	1	12	1	10	.....	8	4	13	4
Holmes	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....
Jackson	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....
Jefferson	2	1	1	.....	1	1	2	1	2	3	4	2	2	4
Knox	.....	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	.....	.....	.....
Licking	.....	2	5	2	2	.....	1	.....	.....	.....	4	2	.....	1
Lorain	.....	1	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....
Medina	.....	.....	.....	1	.....	.....	.....	.....	.....	1	.....	4	1	.....
Monroe	2	1	2	.....	5	.....	5	.....	7	6	5	1	11	.....
Morgan	2	1	1	1	7	2	2	4	4	1	4	1	5	2
Muskingum	3	.....	2	.....	8	6	3	.....	4	1	1	1	9	2
Noble	.....	3	2	5	2	3	3	4	1	8	3	2	.....	.....
Perry	7	1	5	.....	1	3	6	1	17	.....	19	2	12	1
Richland	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....
Tuscarawas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Vinton	3	3	1	4	3	5	2	1	2	4	4	1	3	4
Washington	21	13	18	14	22	9	27	22	34	19	30	21	32	18
Wayne	.....	1	.....	4	.....	.....	.....	2	.....	.....	1	.....	.....	2
	66	40	56	41	60	37	74	44	97	53	92	48	101	51

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Oil wells and dry holes drilled in central and southeastern Ohio in 1916—Continued.

County.	August.		September.		October.		November.		December.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Ashland	.....	6	.....	2	.....	2	.....	5	.....	.....	1	22
Ashtabula	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Athens	3	.....	.....	.....	.....	.....	.....	.....	3	1	16	4
Belmont	1	1	.....	1	.....	.....	1	1	3	2	14	9
Carroll	1	2	3	2	.....	1	1	.....	2	.....	19	9
Columbiana	.....	1	.....	1	1	.....	1	1	1	1	16	18
Coshocton	.....	1	.....	.....	.....	2	.....	.....	.....	.....	4	3
Cuyahoga	1	2	1	3	.....	2	.....	2	1	.....	19	29
Fairfield	3	.....	1	2	.....	1	.....	.....	1	2	13	9
Harrison	2	2	.....	.....	1	.....	1	.....	.....	2	13	9
Hocking	9	4	7	5	3	.....	11	5	6	1	95	27
Holmes	.....	1	1	1	.....	.....	.....	.....	3	.....	6	3
Jackson	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Jefferson	5	3	4	1	7	1	3	1	6	4	39	22
Knox	1	.....	.....	.....	1	.....	.....	.....	.....	.....	5	.....
Licking	1	.....	2	1	.....	.....	.....	3	3	2	18	13
Lorain	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
Medina	1	.....	.....	2	.....	.....	.....	.....	1	.....	3	8
Monroe	5	3	2	2	4	.....	10	2	2	2	60	17
Morgan	.....	1	3	2	2	3	2	1	3	1	35	20
Muskingum	10	4	7	1	11	.....	5	2	8	1	71	18
Noble	1	1	5	.....	.....	2	2	2	3	1	22	31
Perry	8	4	9	2	6	1	6	1	8	2	104	13
Richland	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
Tuscarawas	.....	.....	.....	.....	1	.....	.....	.....	1	2	2	2
Vinton	2	1	2	1	2	1	1	4	.....	.....	25	29
Washington	35	13	30	13	32	15	20	10	25	16	326	183
Wayne	.....	.....	.....	2	.....	2	.....	3	.....	.....	1	16
	89	51	77	44	71	33	64	43	80	40	927	525

Wells completed in central and southeastern Ohio, 1912–1916.

Month.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
January	45	66	105	55	66	31	45	52	42	40	90	140	197	128	144
February	49	78	86	39	56	17	51	51	29	41	83	165	165	158	144
March	48	95	76	49	69	28	36	29	42	37	97	151	121	166	125
April	65	94	112	58	74	26	44	54	40	44	113	148	193	152	135
May	79	123	180	50	97	33	46	50	36	53	127	184	190	123	176
June	89	110	88	50	92	32	49	48	31	48	158	172	182	134	168
July	86	101	83	47	101	50	50	57	36	51	177	174	224	119	185
August	81	131	70	51	89	49	61	56	52	51	163	227	180	161	177
September	71	122	27	54	77	65	49	28	27	44	196	200	142	139	163
October	94	120	42	61	71	51	57	37	35	33	203	224	151	158	133
November	65	105	32	79	61	41	49	35	54	43	156	200	148	218	151
December	74	100	42	84	86	37	66	20	48	40	154	206	151	184	153
	846	1,246	863	677	927	460	603	517	472	525	1,717	2,191	2,044	1,910	1,854

[a] Including gas wells.

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Initial daily production of new wells completed in central and southeastern Ohio in 1916, in barrels.

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Ashland	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10
Athens	.....	.....	.....	.....	15	.....	9	4	.....	.....	.....	5	33
Belmont	19	10	10	.....	2	3	3	10	.....	.....	5	55	117
Carroll	10	20	5	11	1	15	5	1	7	.....	5	53	133
Columbiana	6	2	1	2	2	.....	6	.....	.....	1	1	2	23
Coshocton	.....	4	30	.....	.....	.....	3	.....	.....	.....	.....	.....	37
Cuyahoga	127	50	.....	68	20	25	65	5	20	.....	.....	15	395
Fairfield	30	.....	.....	10	20	23	10	30	3	.....	.....	1	127
Harrison	3	20	15	1	3	.....	5	8	.....	2	2	.....	59
Hocking	130	209	50	650	129	360	243	340	230	100	550	270	3,261
Holmes	.....	.....	.....	.....	.....	3	.....	.....	10	.....	.....	40	53
Jefferson	7	2	1	7	4	9	16	61	10	22	13	29	181
Knox	.....	.....	.....	.....	23	.....	.....	40	.....	10	.....	.....	73
Licking	.....	138	30	20	.....	75	.....	4	30	.....	.....	75	372
Medina	.....	.....	.....	.....	.....	.....	25	20	.....	.....	.....	15	60
Monroe	33	45	54	37	24	22	55	22	6	7	65	12	382
Morgan	2	2	32	4	19	8	9	.....	7	2	6	7	98
Muskingum	10	7	19	47	108	5	160	99	33	299	110	105	1,002
Noble	.....	3	9	11	8	5	.....	6	8	.....	6	8	64
Perry	149	72	25	258	255	371	96	226	256	387	30	162	2,287
Tuscarawas	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	2	4
Vinton	62	2	9	25	37	49	15	15	10	17	5	.....	246
Washington	172	110	149	204	147	165	171	175	149	145	99	110	1,796
Wayne	.....	.....	.....	.....	.....	25	.....	.....	.....	.....	.....	.....	25
	770	696	439	1,355	817	1,163	896	1,066	779	994	897	966	10,838

Total and average initial daily production of new wells in central and southeastern Ohio, 1912–1916, by counties, in barrels.

County.	Total initial production.					Average per well.				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Ashland	.....	20	50	5	10	.....	20.0	25.0	5.0	10.0
Athens	8	39	14	42	33	2.7	2.6	2.0	2.6	2.1
Belmont	553	710	318	92	117	61.4	33.8	21.2	7.7	8.4
Carroll	14	62	72	128	133	2.8	3.0	2.5	5.3	7.0
Columbiana	21	105	278	93	23	5.3	3.7	4.8	2.5	1.4
Coshocton	86	152	82	.....	37	9.6	10.1	6.3	.....	9.3
Cuyahoga	45	.....	78	215	395	11.3	.....	11.1	16.5	20.8
Fairfield	494	1,227	530	97	127	19.8	27.9	21.2	8.1	9.8
Guernsey	.....	45	.....	.....	.....	.....	4.1	.....	.....	.....
Harrison	59	86	57	35	59	5.4	4.5	3.4	2.9	4.5
Hocking	2,986	3,638	4,711	3,816	3,261	40.4	46.6	48.6	53.7	34.3
Holmes	.....	2	.....	.....	53	.....	2.0	.....	.....	8.8
Jefferson	135	218	101	53	181	4.5	3.6	3.1	3.3	4.6
Knox	.....	10	.....	100	73	.....	10.0	.....	100.0	14.6
Licking	734	857	330	383	372	19.8	22.6	20.6	23.9	20.7
Lorain	10	15	.....	.....	.....	10.0	15.0	.....	.....	.....
Medina	.....	.....	.....	35	60	.....	.....	.....	8.8	20.0
Monroe	784	912	348	338	382	11.2	9.1	6.8	9.4	6.4
Morgan	781	454	361	210	98	6.6	3.2	4.0	3.3	2.8
Muskingum	393	107	105	311	1,002	21.8	5.1	7.0	16.4	14.1
Noble	93	318	169	93	64	4.9	5.1	3.8	2.6	2.9
Perry	15,117	4,785	2,806	1,021	2,287	84.0	27.8	25.1	24.9	22.0
Tuscarawas	.....	.....	.....	.....	4	.....	.....	.....	.....	2.0
Vinton	5	.....	.....	96	246	5.0	.....	.....	16.0	9.8
Washington	1,290	1,676	1,307	1,210	1,796	6.3	4.5	5.9	5.0	5.5
Wayne	585	864	330	.....	25	41.8	34.6	36.7	.....	25.0
	24,193	16,302	12,047	8,373	10,838	28.6	13.1	14.0	12.4	11.7

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Total initial daily production of new wells in central and southeastern Ohio, 1912–1916, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1912	1,737	3,577	1,992	1,944	2,309	2,067	2,077	2,518	1,039	2,199	1,006	1,728	24,193	2,016
1913	871	1,116	1,241	1,023	1,328	1,282	1,507	1,609	1,559	2,159	1,784	823	16,302	1,359
1914	1,851	1,318	1,541	1,254	1,808	716	943	851	467	651	240	407	12,047	1,004
1915	658	642	493	534	723	777	466	345	782	675	901	1,377	8,373	698
1916	770	696	439	1,355	817	1,163	896	1,066	779	994	897	966	10,838	903

In the following tables are shown the statistics of oil wells in the Lima district during the last five years:

Wells completed in the Lima district, 1912–1916.

County.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Allen	54	138	71	9	35	2	5	4	.....	2	56	143	75	9	37
Auglaize	7	19	24	4	13	4	7	6	3	10	11	27	30	8	23
Crawford	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Erie	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	2	.....
Hancock	101	172	120	36	106	7	20	19	4	5	116	193	144	40	114
Hardin	.....	.....	2	.....	.....	.....	.....	2	.....	.....	.....	.....	4	.....	1
Henry	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....
Lucas	18	29	39	3	5	2	8	3	1	.....	21	37	42	6	5
Mercer	11	40	15	3	51	1	5	2	1	7	12	45	17	4	59
Ottawa	7	24	17	4	25	2	3	.....	.....	.....	9	29	17	5	26
Putnam	.....	2	3	.....	.....	.....	.....	.....	.....	1	.....	2	3	.....	1
Sandusky	53	104	145	27	79	8	5	6	1	5	62	109	152	28	85
Seneca	29	35	23	17	53	9	7	6	6	15	40	43	29	23	68
Shelby	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....
Van Wert	19	38	41	5	33	1	4	2	1	5	21	42	45	6	38
Wood	177	271	263	116	216	18	23	19	7	21	196	298	288	127	240
Wyandot	4	1	.....	.....	.....	.....	2	.....	1	.....	4	3	2	3	1
Miscellaneous	2	.....	.....	.....	.....	1	1	.....	.....	1	3	1	.....	.....	.....
	482	873	765	224	616	55	90	69	27	72	551	972	850	261	699

[a] Including gas wells.

Oil wells and dry holes drilled in the Lima district in 1916.

County.	January.		February.		March.		April.		May.		June.		July.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Allen	3	.....	1	.....	3	.....	4	1	2	.....	3	.....	3	.....
Auglaize	1	2	.....	1	2	.....	1	.....	2	.....	1	2	1	1
Hancock	4	.....	3	.....	5	.....	9	.....	8	1	9	.....	12	1
Lucas	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	2	.....
Mercer	.....	.....	.....	.....	1	.....	3	.....	4	.....	7	.....	4	2
Ottawa	1	.....	1	.....	1	.....	1	.....	.....	.....	3	.....	2	.....
Putnam	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Sandusky	3	1	4	.....	9	.....	7	.....	8	.....	8	3	9	.....
Seneca	4	3	3	1	3	1	7	.....	5	4	9	.....	6	1
Van Wert	3	.....	2	2	3	.....	2	.....	6	1	4	1	2	.....
Wood	8	.....	7	1	17	1	22	4	22	1	21	2	22	3
Wyandot	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....
	27	6	21	5	45	2	56	5	57	8	65	8	63	8

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Oil wells and dry holes drilled in the Lima district in 1916—Continued.

County.	August.		September.		October.		November.		December.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Allen	3	.....	3	1	5	.....	5	.....	.....	.....	35	2
Auglaize	1	.....	.....	1	2	3	.....	.....	2	.....	13	10
Hancock	13	2	13	1	14	.....	10	.....	7	.....	106	5
Lucas	.....	.....	1	.....	.....	.....	.....	.....	1	.....	5	.....
Mercer	7	.....	8	2	8	.....	6	3	3	.....	51	7
Ottawa	2	.....	4	.....	2	.....	4	.....	4	.....	25	.....
Putnam	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1
Sandusky	9	.....	7	.....	5	1	7	.....	3	.....	79	5
Seneca	3	1	4	1	2	1	3	2	2	.....	53	15
Van Wert	3	.....	2	.....	1	.....	4	1	1	.....	33	5
Wood	32	3	17	4	13	.....	23	1	12	1	216	21
Wyandot	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
	72	6	59	10	88	5	64	8	35	1	616	72

Wells completed in the Lima district, 1912–1916.

Month.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
January	15	48	84	9	27	1	4	5	1	6	18	53	91	10	34
February	17	39	74	19	21	1	3	6	3	5	20	43	82	24	28
March	22	57	65	12	45	4	8	3	2	2	28	65	70	15	47
April	31	41	63	18	56	3	10	11	2	5	34	52	74	20	62
May	43	70	94	15	57	5	8	10	2	8	50	78	104	18	65
June	44	73	75	13	65	5	6	14	2	8	49	80	89	16	73
July	43	98	75	12	63	5	6	4	6	8	48	107	80	21	71
August	46	102	71	21	72	7	16	4	4	6	53	119	76	25	78
September	54	83	66	22	59	16	13	5	.....	10	66	96	72	22	71
October	43	88	39	21	52	5	8	6	2	5	48	96	49	24	59
November	62	86	25	38	64	7	4	.....	.....	8	71	90	26	39	74
December	62	88	34	24	35	2	4	1	3	1	66	93	37	27	37
	482	873	765	224	616	55	90	69	27	72	551	972	850	261	699

[a] Including gas wells.

Initial daily production of new wells completed in the Lima district in 1916, in barrels.

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Allen	40	20	19	45	25	53	30	35	33	60	80	.....	440
Auglaize	20	.....	18	1	8	30	10	25	.....	20	.....	70	202
Hancock	20	36	103	76	160	98	164	84	124	220	194	135	1,414
Lucas	.....	.....	5	.....	.....	.....	30	.....	1	.....	.....	3	39
Mercer	.....	.....	25	55	70	86	140	157	257	237	44	13	1,084
Ottawa	10	8	25	1	.....	34	18	15	35	30	34	55	265
Sandusky	30	40	53	46	50	45	87	55	46	42	32	11	537
Seneca	159	163	70	321	21	197	42	282	65	40	172	55	1,587
Van Wert	56	28	53	6	136	175	100	35	16	10	160	25	800
Wood	147	180	371	308	260	262	323	259	182	202	241	222	2,957
	482	475	742	859	730	980	944	947	759	861	957	589	9,325

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Total and average initial daily production of new wells in the Lima district, 1912–1916, by counties, in barrels.

County.	Total initial production.					Average per well.				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Allen	699	1,888	762	120	440	12.9	13.6	10.7	13.3	12.6
Auglaize	47	142	285	25	202	6.7	7.5	11.9	6.3	15.5
Hancock	1,379	2,924	1,543	422	1,414	13.7	17.0	12.9	11.7	13.3
Hardin	.....	.....	61	.....	.....	.....	.....	30.5	.....	.....
Henry	.....	.....	3	.....	.....	.....	.....	3.0	.....	.....
Lucas	172	373	792	26	39	9.5	12.9	20.3	8.7	7.8
Mercer	111	573	183	38	1,064	10.1	14.4	12.2	12.7	21.3
Ottawa	36	148	117	46	265	5.1	6.2	6.9	11.5	10.6
Putnam	.....	7	43	.....	.....	.....	3.5	14.3	.....	.....
Sandusky	266	625	764	106	537	5.0	6.0	5.3	3.9	6.8
Seneca	1,041	713	713	1,554	1,587	35.9	20.4	31.0	91.4	29.9
Shelby	.....	.....	10	.....	.....	.....	.....	10.0	.....	.....
Van Wert	272	379	530	58	800	14.3	10.0	12.7	11.6	24.2
Wood	3,153	3,404	3,523	2,101	2,957	17.8	12.6	13.4	18.1	13.7
Wyandot	37	10	.....	.....	.....	9.3	10.0	.....	.....	.....
Miscellaneous	16	.....	.....	.....	.....	8.0	.....	.....	.....	.....
	7,229	11,181	9,329	4,496	9,325	15.0	12.8	12.2	20.1	15.1

Total daily initial production of new wells in the Lima district, 1912–1916, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1912	192	221	983	440	619	767	643	781	743	463	839	538	7,229	602
1913	709	439	599	632	871	1,206	1,243	1,414	898	923	1,222	1,025	11,181	932
1914	959	916	1,057	759	967	1,088	1,117	657	697	277	221	614	9,329	777
1915	68	845	178	332	168	287	141	273	700	592	666	246	4,496	375
1916	482	475	742	859	730	980	944	947	759	861	957	589	9,325	777

LIMA-INDIANA OIL FIELD.[1]

GENERAL STATEMENT.

The Lima-Indiana field embraces all areas of oil production in the northwestern part of Ohio and in Indiana. Petroleum in this field is derived from strata belonging to the Ordovician, Silurian, and Carboniferous systems, the principal source being porous dolomitic lenses in the "Trenton" limestone of the Ordovician system. In the detached pools of western Indiana production is derived from the "Corniferous" limestone, of the Devonian system, and from sandstone in the Chester group of the Mississippian series (lower Carboniferous). The occurrence of the oil is in terraces or other minor structures on the flanks of the Cincinnati uplift or simply in porous lenses in limestone strata of uninterrupted dip.

[1] See footnote on p. 742.

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MARKETED PRODUCTION.

Petroleum marketed in the Lima-Indiana field in 1915 and 1916, in barrels.

Month.	1915			1916		
	Lima, Ohio.	Indiana.	Total.	Lima, Ohio.	Indiana.	Total.
January	271,437	82,390	353,827	247,491	57,063	304,554
February	274,450	85,690	360,140	252,535	60,731	313,266
March	311,095	76,939	388,034	287,652	61,260	348,912
April	313,775	82,683	396,458	271,492	63,195	334,687
May	283,022	75,922	358,944	287,382	69,660	357,042
June	295,378	78,934	374,312	277,206	69,725	346,931
July	291,978	72,189	364,167	265,272	66,191	331,463
August	275,442	66,452	341,894	269,449	72,841	342,290
September	276,998	62,010	339,008	250,038	67,462	317,500
October	278,632	66,332	344,964	260,332	65,937	326,269
November	261,197	58,447	319,644	248,223	57,596	305,819
December	260,429	67,770	328,199	218,895	57,375	276,270
	3,393,833	875,758	4,269,591	3,135,967	769,036	3,905,003

Petroleum marketed in the Lima-Indiana field since 1886.

Year.	Marketed production (barrels).	Percentage of total production.	Increase or decrease.		Value.	Yearly average price per barrel.
			Barrels.	Per cent.		
1886	1,137,969	4.06	.....	.....	$444,198	$0.390
1887	4,650,375	16.44	+3,512,506	+308.69	953,327	.205
1888	9,682,683	35.07	+5,032,308	+108.21	1,452,402	.150
1889	12,186,564	34.66	+2,503,881	+ 25.86	1,833,359	.150
1890	15,078,378	32.91	+2,891,814	+ 23.73	4,536,927	.301
1891	17,452,612	32.15	+2,374,234	+ 15.75	5,333,797	.306
1892	15,867,575	31.41	−1,585,037	− 9.08	5,814,629	.366
1893	15,982,097	33.00	+ 114,522	+ .75	7,497,597	.469
1894	17,296,510	35.05	+1,314,413	+ 8.22	8,306,025	.480
1895	20,236,741	38.26	+2,940,231	+ 17.00	14,184,256	.700
1896	25,255,870	41.43	+5,019,129	+ 24.80	16,678,028	.660
1897	22,805,033	37.71	−2,450,837	− 9.70	10,848,097	.476
1898	20,321,323	36.71	−2,483,710	− 10.89	12,458,904	.613
1899	20,225,356	35.44	− 95,967	− .47	18,082,723	.894
1900	21,758,750	34.20	+1,533,394	+ 7.58	21,367,287	.982
1901	21,933,379	31.61	+ 174,629	+ .80	18,734,438	.854
1902	23,358,626	26.31	+1,425,247	+ 6.50	20,810,694	.890
1903	24,080,264	23.97	+ 721,638	+ 3.09	27,825,466	1.155
1904	24,689,184	21.09	+ 608,920	+ 2.53	26,970,803	1.092
1905	22,294,171	16.55	−2,395,013	− 9.70	19,466,901	.873
1906	17,554,661	13.88	−4,739,510	− 21.26	15,927,707	.907
1907	13,121,094	7.90	−4,433,567	− 25.26	11,962,410	.912
1908	10,032,305	5.62	−3,088,789	− 23.54	10,065,768	1.003
1909	8,211,443	4.48	−1,820,862	− 18.15	7,449,107	.907
1910	7,253,961	3.46	− 957,582	− 11.66	5,750,104	.793
1911	6,231,164	2.83	−1,022,697	− 14.10	5,116,954	.821
1912	a 4,925,906	2.21	−1,305,258	− 20.95	4,794,784	.932
1913	4,773,138	1.93	− 152,768	− 3.10	6,588,068	1.380
1914	5,062,543	1.90	+ 289,405	+ 6.07	5,983,356	1.182
1915	4,269,591	1.52	− 792,952	− 15.66	4,114,228	.964
1916	3,905,003	1.298	− 364,588	− 8.54	6,117,369	1.567
	441,634,069	11.274	.....	.....	327,470,113	.741

a Includes production of Michigan.

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Petroleum marketed in the Lima-Indiana field in 1915 and 1916, by districts.

District.	Marketed production (barrels).		Decrease.	
	1915	1916	Barrels.	Per cent.
North Lima	2,826,974	2,594,584	232,390	8.22
South Lima	566,859	541,383	25,476	4.49
Indiana	875,758	769,036	106,722	12.19
	4,269,591	3,905,003	364,588	8.54

Petroleum marketed, value, and average price per barrel in the Lima-Indiana field, 1907–1916.

Year.	North Lima, Ohio.			South Lima, Ohio.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrell.
1907	6,399,917	$6,016,238	$0.940	1,593,140	$1,409,242	$0.885
1908	5,430,124	5,574,400	1.027	1,318,552	1,287,485	.977
1909	4,761,065	4,434,277	.931	1,154,292	1,017,220	.881
1910	4,131,060	3,431,618	.831	963,076	750,011	.779
1911	3,676,397	3,221,308	.876	859,478	666,811	.776
1912	a3,237,926	3,237,849	1.000	717,971	670,960	.934
1913	3,144,968	4,403,858	1.400	672,075	904,964	1.346
1914	3,077,007	3,687,742	1.198	650,080	747,572	1.150
1915	2,826,974	2,767,825	.979	566,859	533,008	.940
1916	2,594,584	4,054,482	1.563	541,383	855,222	1.580

Year.	Indiana.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1907	5,128,037	$4,536,930	$0.885	13,121,094	$11,962,410	$0.912
1908	3,283,629	3,203,883	.976	10,032,305	10,065,768	1.003
1909	2,296,086	1,997,610	.870	8,211,443	7,449,107	.907
1910	2,159,725	1,568,475	.726	7,253,861	5,750,104	.793
1911	1,695,289	1,228,835	.725	6,231,164	5,116,954	.821
1912	970,009	885,975	.913	4,925,906	4,794,784	.932
1913	956,095	1,279,226	1.337	4,773,138	6,588,068	1.380
1914	1,335,456	1,548,042	1.159	5,062,543	5,983,356	1.182
1915	875,758	813,395	.929	4,269,591	4,114,228	.964
1916	769,036	1,207,565	1.570	3,905,003	6,117,269	1.567

a Includes production of Michigan.

Petroleum marketed in the Lima-Indiana field, 1912–1916, in barrels.

Month.	1912	1913	1914	1915	1916
January	318,785	409,902	451,053	353,827	304,554
February	308,755	346,167	326,355	360,140	313,266
March	398,094	336,321	463,922	388,034	348,912
April	459,811	427,768	465,415	396,458	334,687
May	481,496	411,245	457,749	358,944	357,042
June	439,984	390,532	460,915	374,312	346,931
July	455,238	401,394	458,553	364,167	331,463
August	444,752	391,953	429,468	341,894	342,290
September	400,677	400,905	422,501	339,008	317,500
October	437,515	424,560	420,495	344,964	326,269
November	383,094	394,534	363,741	319,644	305,819
December	397,705	437,857	342,376	328,199	276,270
	4,925,906	4,773,138	5,062,543	4,269,591	3,905,003

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Average daily output of petroleum in the Lima-Indiana field, 1912–1916, in barrels.

Month.	1912	1913	1914	1915	1916
January	10,283	13,223	14,550	11,414	9,824
February	10,647	12,363	11,656	12,862	10,902
March	12,842	10,849	14,965	12,517	11,255
April	15,327	14,259	15,514	13,215	11,156
May	15,532	13,266	14,766	11,579	11,518
June	14,666	13,017	15,364	12,477	11,564
July	14,685	12,948	14,792	11,747	10,662
August	14,347	12,644	13,854	11,029	11,042
September	13,356	13,364	14,093	11,300	10,583
October	14,113	13,695	13,564	11,128	10,525
November	12,770	13,151	12,125	10,655	10,194
December	12,829	14,124	11,044	10,387	8,912
Average	13,459	13,077	13,870	11,698	10,669

PIPE-LINE RUNS.

Pipe-line runs in the Lima-Indiana field in 1915 and 1916, in barrels.

Month.	Buckeye pipe line.	Other Ohio lines.	Indiana pipe line.	Other Indiana lines.	Total.
1915.					
January	184,910	86,527	30,312	52,078	353,827
February	186,344	88,106	36,222	49,468	360,140
March	208,454	102,641	29,363	47,576	388,034
April	211,246	102,529	35,967	46,716	396,458
May	191,133	91,889	31,454	44,468	358,944
June	198,569	96,809	34,302	44,632	374,312
July	197,086	94,892	29,992	42,197	364,167
August	184,804	90,638	29,178	37,274	341,894
September	183,651	93,347	27,688	34,322	339,008
October	185,616	93,016	29,578	36,754	344,964
November	175,863	85,314	22,985	35,462	319,644
December	174,113	86,316	26,667	41,103	328,199
	2,281,809	1,112,024	363,708	512,050	4,269,591
1916.					
January	163,324	84,167	21,395	35,668	304,554
February	164,918	87,617	25,325	35,406	313,266
March	188,137	99,515	20,839	40,421	348,912
April	175,247	96,245	25,015	38,180	334,687
May	191,018	96,364	26,809	42,851	357,042
June	185,400	91,806	25,243	44,482	346,931
July	176,591	88,681	24,541	41,650	331,463
August	180,703	88,746	25,102	47,739	342,290
September	167,323	82,715	22,058	45,404	317,500
October	172,535	87,797	22,969	42,968	326,269
November	162,120	86,103	17,435	40,161	305,819
December	147,564	71,331	16,971	40,404	276,270
	2,074,880	1,061,087	273,702	495,334	3,905,003

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Pipe-line runs and deliveries to trade of Lima-Indiana oil and stocks at end of each month in 1915 and 1916, in barrels.

Month.	1915			1916		
	Runs.	Deliveries.	Stocks.	Runs.	Deliveries.	Stocks.
Dec. 31, 1914	.....	.....	1,648,615	.....	.....	.....
January	353,827	303,383	1,699,059	304,554	522,760	2,700,442
February	360,140	228,015	1,831,184	313,266	501,541	2,512,167
March	388,034	236,367	1,982,851	348,912	538,145	2,322,934
April	396,458	217,643	2,161,666	334,687	544,326	2,113,295
May	358,944	161,423	2,359,187	357,042	355,413	2,114,924
June	374,312	160,494	2,573,005	346,931	344,493	2,117,362
July	364,167	118,497	2,818,675	331,463	192,819	2,256,006
August	341,894	275,393	2,885,176	342,290	209,615	2,388,681
September	339,008	278,506	2,945,678	317,500	346,268	2,359,913
October	344,964	269,445	3,021,197	326,269	516,989	2,169,193
November	319,644	329,580	3,011,261	305,819	412,090	2,062,922
December	328,199	420,812	2,918,648	276,270	250,827	2,088,365
	4,269,591	2,999,558	.....	3,905,003	4,735,286	.....

PRICES.

The following table shows the prices of Lima and Indiana oil in 1914–1916, and the dates on which changes in prices became effective.

Prices of Lima and Indiana petroleum in 1914–1916, per barrel.

1914				1915					1916			
Date.	North Lima.	South Lima and Indiana.	Princeton, Ind.	Date.	Lima.		Indiana.	Princeton, Ind.	Date.	Lima.	Indiana.	Princeton, Ind.
					North.	South.						
Jan. 1	$1.49	$1.44	$1.45	Jan. 1	$0.93	$0.88	$0.88	$0.89	Jan. 1	$1.33	$1.18	$1.47
Apr. 18	1.44	1.39	1.40	Feb. 16	.88	.83	.83	.84	Jan. 3	1.43	1.28	1.57
Apr. 25	1.39	1.34	1.35	Feb. 19	.....	.....	.78	.....	Jan. 22	1.48	1.33	.....
Apr. 28	1.34	1.29	1.30	Aug. 12	.....	.....	.....	.89	Jan. 27	1.53	1.38	1.62
May 1	1.29	1.24	1.25	Aug. 20	.93	.88	.....	.94	Feb. 7	1.58	1.43	.....
May 5	1.24	1.19	1.20	Aug. 23	.98	.93	.83	.99	Feb. 16	.....	.....	1.72
May 12	1.19	1.14	1.15	Aug. 30	.....	.98	.....	.....	Mar. 7	1.63	1.48	.....
June 17	1.16	1.11	1.12	Sept. 4	1.03		.88	1.04	Mar. 16	1.73	1.58	1.82
Aug. 1	1.11	1.06	1.07	Sept. 15	1.08		.93	1.09	July 28	1.63	1.48	1.72
Aug. 7	1.06	1.01	1.02	Sept. 27	.....		.....	1.12	Aug. 1	1.58	1.43	1.60
Sept. 15	1.01	.96	.97	Oct. 5	.....		.....	1.17	Aug. 4	1.48	1.33	1.52
Sept. 23	.96	.91	.92	Oct. 23	1.13		.98	1.27	Aug. 14	1.43	1.28	1.47
Oct. 26	.93	.88	.89	Nov. 15	1.18		1.03	1.32	Nov. 18	1.48	1.33	1.52
				Nov. 17	1.23		1.08	1.37	Dec. 13	1.53	1.38	1.57
				Dec. 3	1.28		1.13	1.42	Dec. 19	1.58	1.43	1.62
				Dec. 15	1.33		1.18	1.47				

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Average monthly prices of Lima and Indiana petroleum in 1914, 1915, and 1916, per barrel.

Month.	1914			1915				1916		
	North Lima.	South Lima and Indiana.	Princeton, Ind.	Lima.		Indiana.	Princeton, Ind.	Lima.	Indiana.	Princeton, Ind.
				North.	South.					
January	$1.49	$1.44	$1.45	$0.93	$0.88	$0.88	$0.89	$1.45	$1.30	$1.57
February	1.49	1.44	1.45	.91	.86	.84	.87	1.57	1.42	1.67
March	1.49	1.44	1.45	.88	.83	.78	.84	1.67	1.52	1.77
April	1.45	1.40	1.41	.88	.83	.78	.84	1.73	1.58	1.82
May	1.21	1.16	1.17	.88	.83	.78	.84	1.73	1.58	1.82
June	1.18	1.13	1.14	.88	.83	.78	.84	1.73	1.58	1.82
July	1.16	1.11	1.12	.88	.83	.78	.84	1.72	1.57	1.81
August	1.07	1.02	1.03	.91	.86	.79	.90	1.46	1.31	1.50
September	1.02	.97	.98	1.05	1.03	.90	1.07	1.43	1.28	1.47
October	.95	.90	.91	1.09	1.06	.94	1.19	1.43	1.28	1.47
November	.93	.88	.89	1.18	1.18	1.03	1.32	1.45	1.30	1.49
December	.93	.88	.89	1.30	1.30	1.15	1.44	1.53	1.38	1.57
Average	1.19	1.15	1.16	.98	.94	.87	.99	1.53	1.43	1.67
Average of North Lima and South Lima and Indiana	1.17			0.93				1.51		

Highest, lowest, and average prices of Lima (Ohio) petroleum, 1907–1916, per barrel.

Year.	Highest.	Lowest.	Average.	Year.	Highest.	Lowest.	Average.
1907	[a] $0.94	[b] $0.85	$0.909	1912	[a] $1.25	[b] $0.79	$0.998
1908	[a] 1.04	[b] .89	1.001	1913	[a] 1.49	[b] 1.20	1.375
1909	[a] 1.04	[b] .79	.906	1914	[a] 1.49	[b] .88	1.17
1910	[a] .84	[b] .77	.804	1915	[a b] 1.33	[b] .88	.96
1911	[a] .84	[b] .77	.801	1916	[a b] 1.78	[a b] 1.33	1.51

[a] North Lima. [b] South Lima.

SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on pages 706–707, which are obtained from reports received directly from the oil producers:

Wells completed in the Lima-Indiana field, 1912–1916.

District.	Oil.					Dry.					Total completed. [a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Lima	482	873	765	224	616	55	90	69	27	72	551	972	850	261	699
Indiana	65	213	470	98	160	20	86	259	86	98	89	311	742	192	266
	547	1,086	1,235	322	776	75	176	328	113	170	640	1,283	1,592	453	965

[a] Including gas wells.

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Oil wells and dry holes drilled in the Lima-Indiana field in 1916.

District.	January.		February.		March.		April.		May.		June.		July.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Lima	27	6	21	5	45	2	56	5	57	8	65	8	63	8
Indiana	9	6	9	7	13	11	9	13	22	14	22	10	15	10
	36	12	30	12	58	13	65	18	79	22	87	18	78	18

District.	August.		September.		October.		November.		December.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Lima	72	6	59	10	52	5	64	8	35	1	616	72
Indiana	14	7	15	5	16	2	9	8	7	5	160	98
	86	13	74	15	68	7	73	16	42	6	776	170

Wells completed in the Lima-Indiana field, 1912–1916.

Month.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
January	17	51	120	14	36	3	6	22	10	12	23	58	145	24	50
February	20	48	119	29	30	2	3	31	5	12	26	52	153	38	45
March	24	70	107	23	58	5	11	33	5	13	31	82	144	30	73
April	34	45	107	29	65	8	10	38	9	18	42	57	145	38	84
May	47	87	168	22	79	5	10	37	9	22	54	97	208	32	102
June	48	89	154	19	87	5	11	48	10	18	54	102	202	30	105
July	50	112	129	20	78	8	13	30	16	18	58	129	162	40	96
August	54	130	111	23	86	9	22	28	10	13	63	156	139	34	99
September	62	101	89	27	74	13	28	25	12	15	77	129	115	41	92
October	52	115	49	27	68	7	23	13	8	7	60	140	67	36	77
November	70	120	33	48	73	7	15	11	13	16	79	137	47	62	92
December	69	118	49	41	42	3	24	14	6	6	74	144	65	48	50
	547	1,086	1,235	322	776	75	176	328	113	170	640	1,283	1,592	453	965

[a] Including gas wells.

Initial daily production of new wells completed in the Lima-Indiana field in 1916, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Lima	482	475	742	859	730	980	944	947	759	861	957	589	9,325
Indiana	296	182	292	148	488	524	282	217	536	271	205	113	3,554
	778	657	1,034	1,007	1,218	1,504	1,226	1,164	1,295	1,132	1,162	702	12,879

Total and average initial daily production of new wells in the Lima-Indiana field, 1912–1916, by districts, in barrels.

District.	Total initial production.					Average per well.				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Lima	7,229	11,181	9,329	4,496	9,325	15.0	12.8	12.2	20.1	15.1
Indiana	1,083	7,393	8,436	2,564	3,554	16.7	34.7	18.0	26.2	22.2
	8,312	18,574	17,765	7,060	12,879	15.2	17.1	14.4	21.9	16.6

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Total initial daily production of new wells in the Lima-Indiana field, 1912–1916, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1912.....	267	281	1,013	490	704	824	690	863	891	635	1,026	628	8,312	693
1913.....	774	710	926	855	1,426	1,673	1,627	1,851	1,654	2,389	2,652	2,037	18,574	1,548
1914.....	1,636	2,129	2,187	1,859	1,944	2,245	1,928	1,067	969	431	372	898	17,765	1,480
1915.....	130	960	329	502	305	512	269	288	829	919	1,109	908	7,060	588
1916.....	778	657	1,034	1,007	1,218	1,504	1,206	1,164	1,295	1,132	1,162	702	12,879	1,073

Oil wells abandoned in the Lima-Indiana field from June, 1905, to December, 1916, by months.

Month.	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	Total.
January.....	.....	54	45	75	149	61	62	59	17	7	50	13	592
February.....	.....	74	83	59	108	66	21	34	21	4	31	28	529
March.....	.....	27	49	129	237	221	114	28	13	30	86	24	958
April.....	.....	47	129	198	98	140	31	86	47	23	55	5	859
May.....	.....	100	194	358	204	457	233	83	37	74	88	7	1,535
June.....	28	82	143	207	347	146	118	122	101	52	63	104	1,513
July.....	53	50	111	191	157	176	141	75	17	82	34	26	1,113
August.....	54	147	170	228	322	198	122	102	71	100	34	15	1,491
September.....	19	87	157	195	267	294	79	117	127	64	33	54	1,493
October.....	158	139	181	144	201	80	137	66	142	59	18	161	1,486
November.....	53	139	177	155	172	100	160	158	38	176	63	80	1,471
December.....	66	117	62	220	156	128	41	80	40	29	59	.....	998
Total, Indiana.....	431	1,063	1,501	2,159	2,418	1,695	1,259	1,010	671	700	614	517	14,038
Total, Lima.....	674	1,059	1,357	1,135	1,127	1,500	1,142	856	601	485	664	668	11,269
Total, Lima-Indiana.....	1,105	2,122	2,858	3,294	3,545	3,195	2,401	1,866	1,272	1,186	1,278	1,185	25,307

Oil wells abandoned in the Lima-Indiana field, June, 1905, to December 31, 1916, by counties.

Lima.		Indiana.	
County.	Number of wells.	County.	Number of wells.
Allen.....	2,440	Adams.....	997
Auglaize.....	866	Blackford.....	1,415
Darke.....	4	Delaware.....	1,400
Hancock.....	1,418	Gibson.....	11
Lucas.....	540	Grant.....	4,216
Mercer.....	389	Hamilton.....	9
Ottawa.....	262	Huntington.....	964
Putnam.....	20	Jay.....	603
Sandusky.....	830	Knox.....	12
Seneca.....	119	Madison.....	87
Shelby.....	10	Marion.....	15
Van Wert.....	679	Miami.....	49
Wood.....	3,362	Pike.....	10
Wyandot.....	330	Randolph.....	219
		Sullivan.....	1
		Wabash.....	16
		Wells.....	4,014
	11,269		14,038

INDIANA.

GENERAL STATEMENT.

The contribution of Indiana to the petroleum supply of the United States in 1916 was 769,036 barrels, a quantity less by 106,722 barrels, or 12 per cent, than the output in 1915, and less than the output in any other year since 1892, when the petroleum industry in this State

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was in its infancy. The cause for this decline lies in the failure of wildcat operations to discover new pools of consequence and in the small returns that can be obtained from wells in proved areas.

The average price received for oil at the wells in Indiana in 1916 was $1.57 a barrel, a price higher by 64 cents than in 1915 and higher than in any other year in the history of the local industry. The total market value of the output in 1916 was $1,207,565, a gain of $394,170, or 48 per cent, over the value of the larger output in 1915.

DEVELOPMENT.

Field activity in Indiana in 1916 was distributed over 15 counties and resulted in the completion of 266 wells, of which 160, or 60 per cent, produced oil, 8 were classed as gassers, and 98, an average of 3 in every 8 drilled, were barren. The new oil wells completed in 1916 were credited with a combined initial daily yield of 3,554 barrels of oil, an average of 22 barrels per well the first day of productive life, or 4 barrels less than the average of the new oil wells completed in 1915.

The greater part of the field activity in this State in 1916 was in the southwestern or Wabash Valley district, only 30 wells being completed during the entire year in the eastern or "Trenton" rock area. Drilling in this area was retarded by a scarcity of cheap fuel and by the fact that there is no probability of completing wells which would yield more than a few barrels daily.

In the western part of the State, Sullivan County led in the number of wells completed and in new production, though the average initial yield per well was less than in 1915. Operations in secs. 31 and 32, Washington Township, Pike County, resulted in the development of a small but "spotted" pool about 4 miles southeast of Petersburg. The completion in September by the Indian Refining Co., of a 50-barrel oil well near Hazelton, Washington Township, Gibson County, north of the Princeton pool, furnished an incentive for further drilling, which resulted in the completion late in December of a second well of smaller capacity, which, however, added encouragement to the belief that a new pool had been discovered.

In strictly wildcat territory two wells were drilled in Jackson Township, Spencer County, near the southern boundary of Indiana, one of which wells is reported to have yielded a small quantity of petroleum. One unsuccessful test was completed in April, in Ohio Township, Warrick County.

In all, 517 exhausted wells were abandoned in Indiana in 1916.

MARKETED PRODUCTION.

Petroleum marketed in Indiana, 1912–1916, in barrels.

Month.	1912	1913	1914	1915	1916
January	64,403	73,237	109,891	82,390	57,063
February	62,991	70,336	97,015	85,600	60,731
March	81,148	57,204	120,508	76,939	61,260
April	92,965	78,764	126,670	82,683	63,195
May	101,102	77,379	128,493	75,922	60,660
June	85,819	73,056	129,855	73,934	60,725
July	90,011	73,838	121,122	72,189	66,191
August	86,492	72,467	109,939	66,452	72,841
September	78,432	81,462	110,299	62,010	67,462
October	83,634	91,368	105,969	66,332	65,937
November	60,733	98,444	88,272	58,447	57,596
December	73,279	108,540	87,393	67,770	57,375
	970,009	956,095	1,335,456	875,758	769,036

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SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on page 707, which are obtained from reports received directly from the oil producers:

Wells completed in Indiana, 1912–1916.

County.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Adams	6	8	4	.....	.....	.....	.....	.....	.....	.....	6	8	4	.....	.....
Blackford	2	9	1	.....	3	2	2	.....	.....	3	4	11	3	.....	6
Clay	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....
Daviess	1	1	.....	1	2	.....	.....	.....	3	.....	2	1	.....	4	2
Decatur	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Delaware	15	47	24	1	1	7	8	8	.....	.....	22	55	32	2	1
Dubois	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....	.....
Gibson	.....	18	3	4	14	.....	1	.....	5	5	.....	19	3	9	19
Grant	1	1	3	.....	3	1	1	.....	1	.....	2	4	4	1	3
Harrison	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....
Jay	11	27	14	1	2	4	6	4	.....	2	20	33	21	2	4
Knox	1	.....	.....	1	.....	4	1	6	5	.....	5	2	6	6	.....
Madison	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Martin	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....	.....
Miami	.....	.....	.....	.....	6	.....	1	2	.....	4	.....	1	2	.....	10
Pike	5	11	6	9	38	1	5	8	12	28	6	20	14	22	69
Putnam	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....
Randolph	4	8	4	1	1	.....	3	1	.....	2	4	11	7	2	3
Shelby	.....	.....	4	1	.....	.....	.....	.....	.....	.....	.....	.....	4	1	.....
Spencer	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....	.....	.....	.....	2
Sullivan	2	75	400	66	79	.....	52	219	52	49	2	132	624	122	132
Vigo	1	.....	3	13	8	.....	.....	2	4	3	1	.....	5	17	11
Wabash	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....
Warrick	.....	.....	.....	.....	.....	.....	.....	.....	2	1	.....	.....	.....	2	1
Wells	6	5	1	.....	2	.....	1	.....	.....	.....	6	6	1	.....	2
Miscellaneous	7	3	.....	.....	.....	1	5	7	.....	.....	9	8	7	.....	.....
	65	213	470	98	160	20	86	259	86	98	89	311	742	192	266

[a] Including gas wells.

Oil wells and dry holes drilled in Indiana in 1916.

County.	January.		February		March.		April.		May.		June.		July.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Blackford	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....
Daviess	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Delaware	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Gibson	.....	1	.....	.....	1	1	1	.....	2	.....	1	.....	.....	.....
Grant	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....
Jay	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Miami	.....	.....	1	.....	.....	.....	1	.....	2	.....	.....	.....	1	2
Pike	2	.....	2	2	3	3	2	4	3	3	6	2	4	2
Randolph	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	2	.....	.....
Spencer	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	.....
Sullivan	7	5	4	5	7	6	5	8	16	9	11	5	8	4
Vigo	.....	.....	2	.....	2	1	.....	.....	1	.....	1	.....	.....	2
Warrick	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....
Wells	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	9	6	9	7	13	11	9	13	22	14	22	10	15	10

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Oil wells and dry holes drilled in Indiana in 1916—Continued.

County.	August.		September.		October.		November.		December.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Blackford	.....	1	1	1	.....	1	.....	.....	.....	.....	3	3
Daviess	.....	.....	.....	.....	1	.....	.....	.....	1	.....	2	.....
Delaware	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	.....
Gibson	2	1	3	1	1	.....	2	1	1	.....	14	5
Grant	1	.....	.....	.....	1	.....	.....	.....	.....	.....	3	.....
Jay	.....	.....	.....	2	1	.....	1	.....	.....	.....	2	2
Miami	.....	.....	.....	.....	2	.....	1	.....	.....	.....	6	4
Pike	4	2	5	.....	3	.....	1	7	3	3	38	28
Randolph	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	2
Spencer	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1
Sullivan	7	3	5	1	5	1	3	.....	1	2	79	49
Vigo	.....	.....	1	.....	.....	.....	.....	.....	1	.....	8	3
Warrick	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Wells	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	2	.....
	14	7	15	5	16	2	9	8	7	5	160	98

Wells completed in Indiana, 1912–1916.

Month.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
January	2	3	36	5	9	2	2	17	9	6	5	5	54	14	15
February	3	9	45	10	9	1	.....	25	2	7	5	9	71	14	17
March	2	13	42	11	13	1	3	30	3	11	3	17	74	15	26
April	3	4	44	11	9	5	.....	27	7	13	8	5	71	18	22
May	4	17	74	7	22	.....	2	27	7	14	4	19	104	14	37
June	4	16	79	6	22	.....	5	34	8	10	5	22	113	14	32
July	7	14	54	8	15	3	7	26	10	10	10	22	82	19	25
August	8	28	40	2	14	2	6	22	6	7	10	37	63	9	21
September	8	18	23	5	15	3	15	20	12	5	11	33	43	19	21
October	9	27	10	6	16	2	15	7	6	2	12	44	18	12	18
November	8	34	8	10	9	.....	11	11	13	8	8	47	21	23	18
December	7	30	15	17	7	1	20	13	3	5	8	51	28	21	13
	65	213	470	98	160	20	86	259	86	98	89	311	742	192	266

[a] Including gas wells.

Initial daily production of new wells completed in Indiana in 1916, in barrels.

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Blackford	.....	.....	.....	.....	.....	33	.....	.....	2	.....	.....	.....	35
Daviess	.....	.....	.....	.....	.....	.....	.....	.....	.....	25	.....	5	30
Delaware	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	.....	5
Gibson	.....	.....	10	5	10	10	.....	13	60	6	11	30	155
Grant	.....	.....	.....	.....	.....	.....	8	5	.....	10	.....	.....	23
Jay	.....	.....	.....	.....	.....	.....	.....	.....	.....	75	70	.....	145
Miami	.....	10	.....	10	.....	.....	30	.....	.....	25	12	.....	87
Pike	70	52	82	10	36	83	61	80	255	51	20	72	872
Randolph	.....	.....	.....	.....	.....	150	.....	.....	.....	.....	.....	.....	15)
Spencer	.....	.....	.....	.....	.....	.....	4	.....	.....	.....	.....	.....	4
Sullivan	226	75	150	123	412	218	179	119	209	61	87	3	1,862
Vigo	.....	45	50	.....	30	30	.....	.....	10	.....	.....	3	168
Wells	.....	.....	.....	.....	.....	.....	.....	.....	.....	18	.....	.....	18
	296	182	292	148	488	524	282	217	536	271	205	113	3,554

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Total and average initial daily production of new wells in Indiana, 1912–1916, by counties, in barrels.

County.	Total initial production.					Average per well.				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Adams	103	73	43	.....	.....	17.2	9.1	10.8	.....	.....
Blackford	7	46	3	.....	35	3.5	5.1	3.0	.....	11.7
Daviess	10	10	.....	15	30	10.0	10.0	.....	15.0	15.0
Delaware	425	1,765	545	5	5	28.3	37.6	22.7	5.0	5.0
Gibson	.....	332	9	28	155	.....	18.4	3.0	7.0	11.1
Grant	5	5	27	.....	23	5.0	5.0	9.0	.....	7.7
Harrison	.....	.....	10	.....	.....	.....	.....	5.0	.....	.....
Jay	204	423	167	4	145	14.6	15.7	11.9	4.0	72.5
Knox	3	.....	.....	1	.....	3.0	.....	.....	1.0	.....
Miami	.....	.....	.....	.....	87	.....	.....	.....	.....	14.5
Pike	150	202	136	204	872	30.0	18.4	22.7	22.7	22.9
Randolph	35	395	80	2	150	8.8	49.4	20.0	2.0	150.0
Shelby	.....	.....	50	10	.....	.....	.....	12.5	10.0	.....
Spencer	.....	.....	.....	.....	4	.....	.....	.....	.....	4.0
Sullivan	15	4,032	7,294	1,750	1,862	7.5	53.8	18.2	26.5	23.6
Vigo	30	.....	50	545	168	30.0	.....	16.7	41.9	21.0
Wabash	.....	.....	20	.....	.....	.....	.....	20.0	.....	.....
Wells	31	50	2	.....	18	5.2	10.0	20.0	.....	9.0
Miscellaneous	65	60	.....	.....	.....	9.3	20.0	.....	.....	.....
	1,083	7,393	8,436	2,564	3,554	16.7	34.8	18.0	26.2	22.2

Total initial daily production of new wells in Indiana, 1912–1916, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1912	75	60	30	50	85	57	47	82	148	172	187	90	1,083	90
1913	65	271	327	223	555	467	384	437	756	1,466	1,430	1,012	7,393	616
1914	677	1,213	1,130	1,100	977	1,257	811	410	272	154	151	284	8,436	703
1915	62	115	151	170	137	225	128	15	129	327	443	662	2,564	214
1916	296	182	292	148	488	524	282	217	586	271	205	113	3,554	296

ILLINOIS OIL FIELD.

GENERAL STATEMENT.

The Illinois field lies wholly within the State of the same name and includes the principal area of oil production along the La Salle anticline in the southeastern part of the State as well as a number of scattered pools of small individual extent in the central and western parts of the State. The oil in this field ranges in gravity from 28° to 40° Baumé and contains varying proportions of both asphalt and paraffin, and is obtained for the most part from sandstone layers in formations belonging to the Pennsylvanian and Mississippian series of the Carboniferous system. This field has been an important contributor to the petroleum supply of the United States since 1906, its output in 1908 reaching a maximum of nearly 34,000,000 barrels. Since that year, its production has declined at an average rate of 6 per cent a year, amounting in 1916 to about 53 per cent of the maximum.

The output of petroleum in Illinois in 1916 was 17,714,235 barrels, a loss of 1,327,460 barrels, or 7 per cent, compared with 1915, that is accounted for by the failure of the drilling campaign in 1916 to discover enough new production to offset the deficit resulting from the normal decline of the old wells.

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Market conditions were never better than in 1916, the average price per barrel for Illinois oil in 1916 being $1.65, compared with 98 cents the year before. As a consequence of this gain of 68 per cent in average price the market value of the entire output of Illinois oil in 1916 was $29,237,168, a sum greater than the value of the production in any other year, 1908, the year of maximum yield, included.

Opening the year at $1.47 a barrel the market price for oil of Illinois grade advanced steadily to $1.82 on March 16, the latter price being maintained firmly until July 28, when the steadily mounting surplus of oil in Kansas and Oklahoma made itself felt as a depressing influence on the market for petroleum from other sources. Between this date and August 14 the price of Illinois oil dropped to $1.47 a barrel, remaining at this level until November 18, when an upward movement began that advanced the quotation to $1.62 before the end of the year.

Stocks of Illinois oil were depleted in 1916 from 11,328,014 barrels at the beginning of the year, to 6,599,972 at its end, the average daily requisition being approximately 13,000 barrels.

DEVELOPMENT.

The incentive provided by the advancing market for Illinois oil in the early months of 1916 and again near the end of the year resulted in the completion of 1,461 new wells, compared with only 757 in 1915. Of these 1,107, or 76 per cent, were credited with an average yield of 22 barrels of oil each the first day of productive life, 36 produced gas only, and 318, an average of 2 in every 9 drilled, were barren. The ratio of dry holes to total completions in 1916 shows improvements over that of 5 to 19 maintained in 1915.

SOUTHEASTERN ILLINOIS.

Cumberland, Coles, Clark, Edgar, and Jasper counties.—In the so-called "shallow-sand" district included in the counties named a total of 307 wells, including 258 oil wells, 7 gas wells, and 42 dry holes, were completed. The average initial capacity of the new oil wells was 16 barrels, a loss of 3 barrels compared with the average in 1915. Considerable effort was directed to the quest for extension of the "shallow-sand" district both to the north into Ashmore Township, Coles County, and to the east into Dolson and Martinsville townships, Clark County; but advance tests in these directions were failures.

Crawford and Lawrence counties.—The "deep-sand" fields of Crawford and Lawrence counties were the centers of the greatest activity in drilling in Illinois in 1916, as indicated by the fact that 55 per cent of the wells completed were in these counties. Of 815 wells completed in these counties 603, or 74 per cent, were credited with an average initial output of 26 barrels of oil each, 26 were gas wells, and 186, an average of about 2 in every 9, were failures. Most of the drilling was restricted by necessity to proved areas as efforts to find extensions and new territory of worth were disappointing. Southeast of Lawrenceville encouraging showings of oil in wells drilled in secs. 15 and 22, Allison Township, Lawrence County, provided an incentive for other wells, which, however, failed to demonstrate the presence of an important pool in this locality. Similarly,

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the inconsistencies of the territory in the southwestern part of LaMotte Township, between Palestine and Duncanville, Crawford County, proved disappointing.

Wabash County.—In the Allendale pool, in secs. 3, 4, 9, and 10 of Wabash Township, Wabash County, 29 wells were completed in 1916. Seventeen of these were oil wells credited with a combined initial yield of 2,325 barrels, an average of 137 barrels each. Wildcat tests seeking extensions of this "spotted" pool toward the south and west were unsuccessful.

SOUTH-CENTRAL ILLINOIS.

Marion County.—The Sandoval pool, in Sandoval Township, Marion County, supported an active development in 1916 that resulted in the completion of 18 oil wells, with an average initial capacity of 11.5 barrels each, and 8 dry holes. Twelve miles northeast of this pool a wildcat test on the Goebel farm, section 29, Alma Township, was barren.

Clinton County.—Drilling activity in Clinton County in 1916 resulted in the completion of 11 oil wells and 23 dry holes. The completion in January, as an oil well, of a test on the Hoffsomier farm, in sec. 12, Breese Township, about 3 miles west of the Carlyle pool, resulted in the drilling of additional tests and the partial development of a small but "spotted" pool in this locality. Wildcat tests in Santa Fe and Germantown townships, this county, were failures.

Bond County.—Wildcat activity in Bond County resulted in barren wells on the Minor farm, sec. 29, Mulberry Grove Township, and on the Stoffelbeck farm, sec. 11, Mills Township.

Macoupin County.—The Carlinville pool, in Brushy Mound Township, passed a featureless year, no new wells having been completed in 1916. Further drilling on the Staunton dome, in Dorchester Township, added 3 gas wells to the gas field opened in 1915 on this structure. Arrangements were completed for the utilization of the gas from this field and a pipe line was laid to Staunton, Edwardsville, Maryville, Collinsville, and Belleville.

SOUTHERN ILLINOIS.

In 1916 three unsuccessful tests for oil were completed in Saline County, located, respectively, in secs. 21 and 35, T. 10 S., R. 5 E., and sec. 9, T. 11 S., R. 5 E.

WESTERN ILLINOIS.

McDonough County.—The proved area of the Hoing and Hamm pools in the Colmar district was essentially drilled up by the completion in 1916 of 211 wells, 186 of which produced an average of 10 barrels of oil each the first 24 hours after completion. In efforts to extend this field 25 dry holes were drilled in McDonough County alone.

Hancock County.—Persistent efforts to extend the Colmar field westward into Hancock County were rewarded in 1916 by the discovery and partial development of a small pool of oil on the Aleshire farms, in secs. 24 and 13, St. Marys Township.

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Henderson County.—Late in 1916 considerable interest was aroused by the discovery of encouraging showings of oil in tests near Biggsville, Henderson County, about 30 miles north of the Colmar district, but to the end of the year the value of these showings had not been demonstrated.

Tazewell County.—Near Tremont, Tazewell County, 4 dry holes and 2 wells that furnished a few gallons of oil each were completed.

Unsuccessful tests.—Unsuccessful tests were completed in 1916 in sec. 5, Birmingham Township, Schuyler County, in sec. 21, Pea Ridge Township, and sec. 5, Missouri Township, Brown County; in sec. 6, New Salem Township, and sec. 23, Beverly Township, Adams County; and in sec. 27, Washington Township, Pike County.

MISCELLANEOUS TESTS.

Unsuccessful wildcat tests were completed in 1916 in Illinois in sec. 13, Otego Township, Fayette County; near Campbell Hill, Jackson County; near Unity and Tamms, Alexander County; near Ullin, Pulaski County; and near Coal City, Grundy County.

MARKETED PRODUCTION.

Petroleum marketed in Illinois, 1889–1916, in barrels.

Year.	Marketed production.	Percentage of total production.	Increase or decrease.		Value.	Yearly average price per barrel.
			Barrels.	Per cent.		
1889	1,460				$4,906	$3.360
1890	900		− 560	− 38.36	3,000	3.333
1891	675		− 225	− 25.00	2,363	3.500
1892	521		− 154	− 22.81	1,823	3.500
1893	400		− 121	− 23.22	1,400	3.500
1894	300		− 100	− 25.00	1,800	6.000
1895	200		− 100	− 33.33	1,200	6.000
1896	250		+ 50	+ 25.00	1,250	5.000
1897	500		+ 250	+ 100.00	2,000	4.000
1898	360		− 140	− 28.00	1,800	5.000
1899	360				1,800	5.000
1900	200		− 160	− 44.44	1,000	5.000
1901	250		+ 50	+ 25.00	1,250	5.000
1902	200		− 50	− 20.00	1,000	5.000
1903			− 200	− 100.00		
1904						
1905	181,084	0.13	+ 181,084		116,561	.644
1906	4,397,050	3.47	+ 4,215,966	+2,328.18	3,274,318	.745
1907	24,281,973	14.62	+19,884,923	+ 452.23	16,432,947	.677
1908	33,686,238	18.87	+ 9,404,265	+ 38.73	22,649,561	.672
1909	30,898,339	16.87	− 2,787,899	− 8.28	19,788,364	.640
1910	33,143,362	15.82	+ 2,244,923	+ 7.27	19,669,383	.593
1911	31,317,038	14.21	− 1,826,224	− 5.51	19,734,339	.639
1912	28,601,308	12.83	− 2,715,730	− 8.67	24,332,605	.851
1913	23,893,899	9.62	− 4,707,409	− 16.45	30,971,910	1.296
1914	21,919,749	8.25	− 1,974,150	− 8.26	25,426,179	1.160
1915	19,041,695	6.77	− 2,878,054	− 13.13	18,655,350	.980
1916	17,714,235	5.89	− 1,327,460	− 6.97	29,237,168	1.650
	269,082,546	6.869			230,316,777	.856

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Petroleum marketed in Illinois, 1912–1916, in barrels.

Month.	1912	1913	1914	1915	1916
January	2,241,867	2,149,264	1,935,492	1,614,026	1,373,615
February	2,262,440	1,859,412	1,570,790	1,542,383	1,330,016
March	2,369,428	2,008,945	1,969,915	1,761,099	1,552,827
April	2,351,693	2,015,088	1,833,099	1,643,479	1,396,454
May	2,535,039	2,117,425	1,970,688	1,638,733	1,572,217
June	2,503,038	2,003,278	1,932,903	1,603,733	1,527,589
July	2,698,582	2,075,444	1,907,521	1,636,932	1,540,887
August	2,519,651	2,001,228	1,844,983	1,593,436	1,561,066
September	2,366,712	1,942,052	1,817,437	1,535,040	1,467,892
October	2,424,472	1,982,002	1,813,364	1,583,972	1,522,930
November	2,174,856	1,819,116	1,678,783	1,452,285	1,454,302
December	2,153,530	1,921,375	1,645,374	1,486,577	1,414,440
	28,601,308	23,893,899	21,919,749	19,041,695	17,714,235

Average daily output of petroleum in Illinois, 1912–1916, in barrels.

Month.	1912	1913	1914	1915	1916
January	72,318	69,331	62,435	52,065	44,310
February	78,015	66,407	56,100	55,085	45,863
March	76,433	64,782	63,546	56,810	50,091
April	78,390	67,169	61,103	54,783	46,548
May	81,775	68,304	63,570	52,862	50,717
June	83,435	66,776	64,410	53,458	50,920
July	87,051	66,950	61,533	52,804	49,706
August	81,279	64,556	59,516	51,401	50,357
September	78,890	64,735	60,581	51,168	48,930
October	78,209	63,936	58,496	49,483	49,127
November	72,495	60,637	56,959	48,410	48,477
December	69,469	61,980	53,076	47,954	45,627
Average	78,146	65,463	60,054	52,169	48,400

PIPE-LINE RUNS, DELIVERIES, AND STOCKS.

Pipe-line runs and deliveries to trade of petroleum from Illinois and stocks at end of each month in 1915 and 1916, in barrels.

Month.	1915			1916		
	Runs.	Deliveries.	Stocks.	Runs.	Deliveries.	Stocks.
Dec. 31, 1914			13,563,743			
January	1,614,026	2,880,490	12,297,279	1,373,615	1,963,561	10,738,068
February	1,542,383	1,452,630	12,387,032	1,330,016	1,862,876	10,205,208
March	1,761,099	1,596,789	12,551,342	1,552,827	2,055,429	9,702,606
April	1,643,479	1,394,941	12,799,880	1,396,454	1,960,662	9,138,398
May	1,638,733	1,492,208	12,946,345	1,572,217	2,228,099	8,482,516
June	1,603,733	1,286,497	13,263,581	1,527,589	1,789,576	8,220,529
July	1,636,932	2,171,851	12,728,662	1,540,887	2,046,827	7,714,589
August	1,593,436	1,903,128	12,418,970	1,561,066	1,811,639	7,464,016
September	1,535,040	1,754,855	12,199,155	1,467,892	1,809,504	7,122,404
October	1,583,972	1,632,584	12,100,543	1,522,930	1,733,451	6,911,883
November	1,452,285	1,791,176	11,761,652	1,454,302	1,591,840	6,774,345
December	1,486,577	1,920,215	11,328,014	1,414,440	1,588,813	6,599,972
	19,041,695	21,277,424		17,714,235	22,442,277	

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Pipe-line runs, deliveries, and stocks of the Ohio Oil Co. in 1912–1914 and the Illinois Pipe Line Co. in 1915 and 1916 in Illinois, in barrels.

Pipe-line runs.

Month.	1912	1913	1914	1915	1916
January	1,853,266	1,591,944	1,425,574	1,183,446	936,579
February	1,853,379	1,348,292	1,148,926	1,119,973	885,070
March	1,949,945	1,457,711	1,409,331	1,268,446	1,056,212
April	1,916,071	1,456,551	1,328,430	1,159,393	933,335
May	2,084,743	1,551,323	1,434,303	1,155,255	1,057,769
June	2,063,087	1,471,437	1,407,706	1,134,519	1,043,541
July	2,230,164	1,531,800	1,398,849	1,144,094	1,044,236
August	1,996,824	1,483,801	1,371,731	1,112,979	1,071,959
September	1,871,325	1,437,974	1,345,016	1,077,996	1,001,549
October	1,901,119	1,473,679	1,350,167	1,078,114	1,025,055
November	1,668,306	1,360,159	1,246,292	1,013,783	976,503
December	1,594,700	1,420,484	1,222,575	1,016,719	954,199
	23,002,929	17,585,155	16,148,960	13,464,717	11,985,998

Deliveries.[a]

January	1,350,621	1,201,633	936,867	31,910	25,063
February	1,387,078	1,042,834	1,027,022	26,809	24,322
March	1,532,428	1,172,522	749,703	24,703	22,608
April	1,420,013	1,139,433	525,769	23,681	16,681
May	1,301,727	1,226,625	819,105	30,611	106,640
June	1,302,537	1,161,667	752,134	16,192	34,549
July	1,327,329	1,171,492	803,558	15,907	26,372
August	1,306,563	794,844	474,569	21,252	38,132
September	1,359,968	1,039,267	594,960	36,565	21,007
October	1,401,807	1,065,320	630,028	29,727	8,835
November	1,230,357	810,907	256,567	16,551	12,146
December	1,206,516	1,204,375	15,090	14,319	16,174
	16,126,944	13,030,919	7,585,373	288,227	352,529

Stocks.[b]

January	18,393,303	11,118,521	5,508,791	3,351,079	4,588,380
February	17,706,835	10,344,393	5,188,339	3,689,025	4,388,169
March	17,279,112	9,935,612	5,627,743	4,460,698	4,275,128
April	17,001,576	9,446,550	6,500,409	5,177,985	3,968,456
May	16,636,329	8,941,584	7,284,952	5,625,562	3,709,265
June	16,235,353	8,054,011	8,035,036	5,763,894	3,500,393
July	15,689,994	7,548,743	8,682,851	4,990,447	2,043,284
August	14,682,823	6,876,978	9,683,090	5,165,511	2,001,292
September	13,949,064	6,416,698	10,473,407	5,083,656	2,191,174
October	13,039,507	5,748,180	11,033,448	4,979,712	2,163,016
November	12,307,725	5,829,018	11,183,664	4,799,585	2,264,739
December	11,591,427	5,551,556	11,390,608	4,611,579	2,098,910

[a] These deliveries are to trade only. Deliveries to other pipe lines are also made.
[b] Stocks include some Indiana petroleum of Illinois grade.

PRICES.

In the following table are shown the dates of change and the changes in prices at wells of the different grades of petroleum produced in Illinois during the years 1914–1916.

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Prices per barrel of Illinois petroleum in 1914–1916.

1914		1915			1916		
Date.	All grades.	Date.	Illinois.	Plymouth.	Date.	Illinois.	Plymouth.
Jan. 1	$1.45	Jan. 1	$0.89		Jan. 1	$1.47	$1.33
Apr. 18	1.40	Feb. 16	.84		Jan. 3	1.57	
Apr. 25	1.35	Aug. 13	.89	$0.58	Jan. 21		1.38
Apr. 28	1.30	Aug. 20	.94		Jan. 27	1.62	1.43
May 1	1.25	Aug. 23	.99		Feb. 16	1.72	
May 5	1.20	Sept. 4	1.04		Mar. 6		1.53
May 12	1.15	Sept. 10		.78	Mar. 13		1.58
June 17	1.12	Sept. 13		.83	Mar. 16	1.82	1.68
Aug. 1	1.07	Sept. 15	1.09		July 28	1.72	1.58
Aug. 7	1.02	Sept. 27	1.12	.93	Aug. 1	1.62	1.48
Sept. 14	.97	Oct. 5	1.17		Aug. 3		1.38
Sept 23	.92	Oct. 23	1.27		Aug. 4	1.52	
Oct 26	.89	Nov. 15	1.32	1.03	Aug. 14	1.47	1.18
		Nov. 17	1.37	1.13	Aug. 17		1.08
		Dec. 3	1.42		Aug. 28		1.03
		Dec. 14		1.23	Nov. 18	1.52	
		Dec. 15	1.47	1.33	Nov. 30		1.13
					Dec. 13	1.57	1.23
					Dec. 19	1.62	1.33
					Dec. 28		1.43
					Dec. 29		1.53

Average monthly prices per barrel of Illinois petroleum, 1912–1916.

Month.	1912		1913	1914	1915		1916	
	Above 30° B.	Below 30° B.			Illinois.	Plymouth.	Illinois.	Plymouth.
January	$0.72	$0.62	$1.09	$1.45	$0.89		$1.57	$1.36
February	.78	.68	1.21	1.45	.87		1.67	1.43
March	.81	.71	1.25	1.45	.84		1.77	1.60
April	.81	.71	1.28	1.41	.84		1.82	1.68
May	.84	.74	1.30	1.17	.84		1.82	1.68
June	.85	.76	1.30	1.14	.84		1.82	1.68
July	.85	.80	1.30	1.12	.84		1.81	1.67
August	.87	.82	1.30	1.08	.90	$0.58	1.50	1.22
September	.87	.83	1.30	.98	1.07	.76	1.47	1.03
October	.87	.84	1.30	.91	1.19	.93	1.47	1.03
November	.93	.90	1.38	.89	1.32	1.03	1.49	1.03
December	1.04	1.02	1.45	.89	1.44	1.24	1.57	1.26
Average	.853	.786	1.288	1.16	.99	.91	1.65	1.39

SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on page 707, which are obtained from reports received directly from the oil producers:

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Wells completed in Illinois, 1912–1916.

County.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Adams									2					2	
Bond								2		2			2		2
Brown										2					2
Champaign									2					2	
Clark	50	169	157	107	218	12	35	62	33	34	62	208	221	141	256
Clinton	35	14	2		11	13	5	2	2	23	48	19	4	2	34
Coles	1	3	16	2	6	5	3	5	1	5	6	6	21	3	11
Crawford	310	540	542	153	391	96	110	136	54	152	414	669	786	215	569
Cumberland	42	49	22	37	34	8	11	2	4	3	50	61	24	44	40
Edgar				3					1					4	
Edwards									1					1	
Fayette										1					1
Hancock			1		12			19	8	10			20	8	22
Henderson					2					1					3
Jackson	1					4	2		1	1	6	2		1	1
Jasper		2	3			1		2			1	2	5		
Lawrence	495	538	294	128	212	77	69	69	28	34	586	663	365	157	246
McDonough			138	97	186			36	33	25			174	130	211
Macoupin	1	3	3	1			6	2	3	3	1	9	5	10	6
Madison						4		1	1		4		1	1	
Marion	22	21	6	6	18	4	1	1		8	26	22	7	6	26
Montgomery									3					3	
Randolph						1			1		1			1	
St. Clair									2					2	
Saline							2	1		1		2	1		1
Schuyler									17	1				17	1
Wabash	22	24	7	5	17	20	24	5	1	12	42	48	12	6	29
Washington									1					1	
Miscellaneous	1					12	10	11			13	10	11		
	980	1,363	1,191	539	1,107	257	278	356	199	318	1,200	1,721	1,579	757	1,461

[a] Including gas wells.

Oil wells and dry holes drilled in Illinois in 1916.

County.	January.		February.		March.		April.		May.		June.		July.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Bond				2		2								
Brown														
Clark	13	1	9	2	18	1	13	6	22	5	31	7	33	3
Clinton	1		3					3	3	3	2	4	1	4
Coles	1		1								1	1		
Crawford	22	16	16	4	23	13	25	9	35	18	52	19	36	13
Cumberland	3		6	1		2	5		3		1		6	
Fayette										1				
Hancock		4			1	2	2		2	2	3		1	1
Henderson														
Jackson				1										
Lawrence	8	4	10	2	17	2	8	2	21	3	25	4	18	3
McDonough	12	2	12	1	27	4	17		37	4	25	2	17	1
Macoupin				3										
Marion			1			1			2				2	
Saline				1										
Schuyler						1								
Wabash				1	1		1	1	3	1	1		2	1
	60	27	58	18	87	28	71	21	128	37	141	37	116	26

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Oil wells and dry holes drilled in Illinois in 1916—Continued.

County.	August.		September.		October.		November.		December.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Bond	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
Brown	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
Clark	29	4	14	.....	7	.....	20	4	9	1	218	34
Clinton	1	2	.....	2	.....	2	.....	1	.....	2	11	23
Coles	1	.....	.....	1	.....	2	1	1	1	.....	6	5
Crawford	51	14	49	17	31	11	26	9	25	9	391	152
Cumberland	2	.....	4	.....	.....	.....	1	.....	3	.....	34	3
Fayette	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Hancock	1	1	1	.....	.....	.....	1	.....	.....	.....	12	10
Henderson	.....	.....	.....	.....	1	1	.....	.....	1	.....	2	1
Jackson	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Lawrence	25	4	22	4	23	4	24	2	11	.....	212	34
McDonough	14	4	13	2	3	2	9	3	.....	.....	186	25
Macoupin	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3
Marion	.....	.....	6	1	4	5	2	1	1	.....	18	8
Saline	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Schuyler	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Wabash	.....	1	4	1	1	3	2	2	2	1	17	12
	124	30	113	28	70	30	86	23	53	13	1,107	318

Wells completed in Illinois, 1912–1916.

Month.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
January	74	106	126	31	60	7	23	15	14	27	81	131	148	47	94
February	53	83	103	22	58	15	22	28	13	18	71	107	135	37	82
March	44	71	116	40	87	8	12	18	12	28	54	89	136	53	119
April	54	92	148	43	71	17	13	41	10	21	74	105	191	54	93
May	66	137	116	33	128	21	21	35	18	37	91	159	154	53	169
June	96	112	123	36	141	24	35	52	16	37	122	153	180	54	184
July	77	139	98	47	116	44	28	37	16	26	123	170	138	64	143
August	95	116	98	51	124	30	38	39	19	30	126	156	140	71	156
September	88	145	111	49	113	13	16	28	16	28	104	163	139	66	142
October	124	151	69	56	70	21	31	27	19	30	146	181	98	79	103
November	107	115	48	58	86	31	24	14	25	23	139	143	63	84	110
December	102	96	35	73	53	26	15	22	21	13	129	164	57	96	66
	980	1,363	1,191	539	1,107	257	278	356	199	318	1,260	1,721	1,579	757	1,461

[a] Including gas wells.

Initial daily production of new wells completed in Illinois in 1916, in barrels.

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Clark	250	176	645	121	457	374	607	420	184	145	284	74	3,737
Clinton	5	42	.....	.....	85	140	5	14	.....	.....	.....	.....	291
Coles	5	5	.....	.....	.....	10	.....	2	.....	.....	20	15	57
Crawford	206	289	506	325	560	615	627	790	718	532	656	252	6,076
Cumberland	100	80	.....	64	35	5	35	27	66	.....	5	17	434
Hancock	.....	.....	50	45	12	30	10	10	5	.....	5	.....	167
Henderson	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	.....	2	7
Lawrence	279	360	779	126	839	1,225	881	1,566	934	893	1,078	580	9,540
McDonough	139	143	269	175	418	279	187	128	97	40	73	.....	1,948
Marion	.....	10	.....	.....	40	.....	20	.....	71	47	7	12	207
Wabash	.....	.....	125	200	240	150	275	.....	625	200	350	160	2,325
	984	1,105	2,374	1,056	2,686	2,828	2,647	2,957	2,700	1,862	2,478	1,112	24,780

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Total and average initial daily production of new wells in Illinois, 1912–1916, in barrels.

County.	Total initial production.					Average per well.				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Clark	1,178	2,610	1,590	2,014	3,737	23.6	15.4	10.1	18.8	17.1
Clinton	1,127	134	20	.....	291	32.2	9.6	10.0	.....	26.5
Coles	5	75	172	35	57	5.0	25.0	10.7	17.5	9.5
Crawford	7,175	9,990	8,612	1,776	6,076	23.1	18.5	15.9	11.6	15.5
Cumberland	800	595	127	810	434	19.0	12.1	5.8	21.9	12.8
Edgar	.....	.....	.....	6	.....	.....	.....	.....	2.0	.....
Hancock	.....	.....	45	.....	167	.....	.....	45.0	.....	13.9
Henderson	.....	.....	.....	.....	7	.....	.....	.....	.....	3.5
Jackson	3	.....	.....	.....	.....	3.0	.....	.....	.....	.....
Jasper	.....	30	28	.....	.....	.....	15.0	9.3	.....	.....
Lawrence	51,975	32,316	24,324	6,329	9,540	105.0	60.1	82.7	49.4	45.0
McDonough	.....	.....	3,919	2,592	1,948	.....	.....	28.4	26.7	10.5
Macoupin	3	165	15	5	.....	3.0	55.0	5.0	5.0	.....
Marion	610	492	70	270	207	27.7	23.4	11.6	45.0	11.5
Wabash	2,235	998	345	328	2,325	101.6	41.6	49.3	65.6	136.8
Miscellaneous	575	.....	.....	.....	.....	575.0	.....	.....	.....	.....
	65,686	47,405	39,268	14,165	24,789	67.0	34.8	33.0	26.3	22.4

Total initial daily production of new wells in Illinois, 1912–1916, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1912	3,884	4,367	2,323	3,768	4,013	10,761	6,879	6,114	4,679	7,367	7,104	4,508	65,686	5,474
1913	4,000	3,896	2,337	3,702	4,170	3,715	4,637	3,581	4,662	4,643	3,641	4,428	47,405	3,950
1914	2,925	3,415	2,443	4,838	5,552	6,542	3,801	2,792	2,925	1,517	1,156	1,362	39,268	3,272
1915	975	640	1,478	1,254	953	1,219	1,366	1,367	1,236	1,263	1,151	1,263	14,165	1,180
1916	984	1,105	2,374	1,056	2,686	2,828	2,617	2,957	2,700	1,862	2,478	1,112	24,789	2,066

MID-CONTINENT OIL FIELD.

GENERAL STATEMENT.

For commercial purposes it is customary to group under the title "Mid-Continent field" the areas of oil production in Kansas, Oklahoma, northern and central Texas, and northern Louisiana. In Kansas, Oklahoma, and northern Texas petroleum is derived mainly from sandstone layers included in formations of the Pennsylvanian series (upper Carboniferous). In southern Oklahoma sandstone layers in the "Red Beds" of the Permian series (latest Carboniferous) form the reservoirs of oil in the Healdton district. In northern Louisiana and central Texas the oil is found in sandstones or other porous rocks belonging to the Cretaceous and Tertiary systems. The occurrence of oil throughout the Mid-Continent field is in anticlines, domes, half-domes, and terraces on the flanks of major uplifts, such as the Ozark, Wichita, Arbuckle, and Sabine.

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MARKETED PRODUCTION.

Petroleum marketed in the Mid-Continent field in 1915 and 1916, in barrels.

Month.	Kansas.	Oklahoma.	Northern Texas.	Northern Louisiana.	Total.
1915.					
January	245,606	6,356,310	637,664	816,369	8,056,449
February	207,411	6,553,703	574,417	902,532	8,238,063
March	226,183	7,428,935	623,017	1,069,387	9,347,522
April	209,173	11,250,823	677,526	1,168,191	13,305,713
May	211,159	7,762,963	714,366	1,271,150	9,959,638
June	217,838	8,363,142	674,812	1,240,980	10,496,652
July	239,216	9,113,460	643,947	1,505,859	11,502,482
August	247,029	7,966,760	621,201	1,653,871	10,488,861
September	252,748	7,874,149	583,910	1,592,323	10,303,130
October	259,494	7,843,458	583,364	1,346,369	10,032,685
November	262,955	7,923,966	562,337	1,268,339	10,017,997
December	244,675	9,477,174	576,992	1,246,284	11,545,125
	2,823,487	97,915,243	7,473,553	15,082,034	123,294,317
1916.					
January	197,348	8,441,229	611,714	1,149,990	10,400,281
February	284,726	8,763,238	603,151	1,074,334	10,725,449
March	353,603	9,631,738	691,735	1,136,331	11,813,497
April	441,422	8,621,433	716,428	1,067,309	10,846,592
May	633,726	9,355,086	812,771	1,099,704	11,901,287
June	834,640	9,047,460	856,993	1,042,337	11,781,430
July	705,376	8,750,160	889,391	997,816	11,342,743
August	644,667	8,474,831	864,838	947,898	10,932,234
September	951,516	8,761,698	810,743	877,052	11,401,009
October	1,260,585	9,399,483	841,068	876,284	12,377,420
November	1,212,459	8,797,850	800,492	776,036	11,586,837
December	1,217,919	9,027,509	803,681	776,551	11,825,660
	8,738,077	107,071,715	9,303,005	11,821,642	136,934,439
Increase or decrease, 1916:					
Barrels	+5,914,590	+9,156,472	+1,829,452	−3,260,392	+13,640,122
Per cent	+ 209.48	+ 9.35	+ 24.48	− 21.62	+ 11.06

Petroleum marketed in the Mid-Continent field, 1889–1916.

Year.	Marketed production (barrels).	Percentage of total production.	Increase or decrease.		Value.	Yearly average price per barrel.
			Barrels.	Per cent.		
1889	500	.....	.....	.....	$2,500	$5.000
1890	1,200	.....	+ 700	+140.00	8,400	7.000
1891	1,430	.....	+ 230	+ 19.17	9,950	6.958
1892	5,080	.....	+ 3,650	+255.24	5,480	1.079
1893	18,010	0.04	+ 12,930	+254.53	18,060	1.003
1894	40,130	.08	+ 22,120	+122.82	40,810	1.017
1895	44,467	.08	+ 4,337	+ 10.81	26,910	.605
1896	115,141	.19	+ 70,674	+158.93	52,587	.457
1897	147,648	.24	+ 32,507	+ 28.23	71,914	.487
1898	616,600	1.11	+ 468,952	+317.62	305,875	.496
1899	738,183	1.29	+ 121,583	+ 19.72	523,068	.709
1900	917,225	1.44	+ 179,042	+ 24.25	945,992	1.031
1901	989,696	1.43	+ 72,471	+ 7.90	778,097	.787
1902	986,720	1.12	− 2,976	− .30	745,803	.756
1903	1,573,085	1.57	+ 586,365	+ 59.42	1,645,936	1.046
1904	6,186,629	5.28	+ 4,613,544	+293.28	5,859,982	.947
1905	12,533,777	9.30	+ 6,347,148	+102.60	6,908,002	.551
1906	22,839,911	18.05	+10,306,134	+ 82.23	10,357,923	.454
1907	46,896,267	28.23	+24,056,356	+105.33	19,239,085	.410
1908	48,823,747	27.35	+ 1,927,480	+ 4.11	19,134,658	.392
1909	50,833,740	27.75	+ 2,009,993	+ 4.12	18,863,436	.371
1910	59,217,582	28.26	+ 8,383,842	+ 16.49	23,163,676	.391
1911	66,595,477	30.21	+ 7,377,895	+ 12.46	31,928,208	.479
1912	65,473,323	29.48	− 1,122,154	− 1.68	45,300,658	.692
1913	84,929,225	34.18	+19,446,902	+ 29.70	80,767,758	.951
1914	[a]97,994,900	36.87	+13,074,675	+ 15.40	78,671,402	.803
1915	123,294,317	43.86	+25,299,417	+ 25.82	72,431,301	.587
1916	136,934,439	45.528	+13,640,122	+ 11.06	162,816,998	1.189
	828,739,449	21.156	.....	.....	580,624,469	.701

[a] Does not include 19,550,000 barrels produced in 1914 in the Cushing and Healdton fields in Oklahoma and placed in field storage.

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Petroleum marketed, value, and average price per barrel in the Mid-Continent field, 1907–1916, by States.

Year.	Kansas and Oklahoma.			Northern Texas.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1907	45,933,649	$18,478,658	$0.402	912,618	$721,577	$0.791
1908	47,600,546	18,441,538	.387	723,264	479,072	.662
1909	49,122,982	17,920,623	.364	681,940	393,732	.577
1910	53,157,386	20,367,423	.383	969,403	505,396	.521
1911	57,348,456	27,060,523	.472	2,251,193	1,213,960	.539
1912	53,019,867	35,768,302	.674	5,275,507	4,112,815	.779
1913	65,954,413	61,830,231	.937	9,184,252	9,125,185	.992
1914	a 76,735,309	59,686,261	.778	9,451,122	7,778,455	.823
1915	100,738,730	58,409,024	.580	7,473,553	4,656,934	.623
1916	115,809,792	138,803,763	1.199	9,303,005	11,834,973	1.272

Year.	Northern Louisiana.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1907	50,000	$38,850	$0.277	46,896,267	$19,239,085	$0.410
1908	499,937	214,048	.428	48,823,747	19,134,658	.392
1909	1,028,818	549,081	.533	50,833,740	18,863,436	.371
1910	5,090,793	2,290,857	.450	59,217,582	23,163,676	.391
1911	6,995,828	3,653,725	.522	66,595,477	31,928,208	.479
1912	7,177,949	5,419,541	.755	65,473,323	45,300,658	.692
1913	9,781,560	9,812,342	1.003	84,920,225	80,767,758	.951
1914	11,808,469	11,206,686	.949	97,994,900	78,671,402	.803
1915	15,082,034	9,365,343	.621	123,294,317	72,431,301	.587
1916	11,821,642	12,178,262	1.030	136,934,439	162,816,998	1.189

a Does not include 19,550,000 barrels produced in 1914 in the Cushing and Healdton fields in Oklahoma and placed in field storage.

Petroleum marketed in the Mid-Continent field, 1912–1916, in barrels.

Month.	1912	1913	1914	1915	1916
January	4,955,460	6,271,174	8,040,953	8,056,449	10,400,281
February	4,895,427	5,951,436	7,246,281	8,238,063	10,725,449
March	5,158,823	6,721,358	9,226,674	9,347,522	11,813,497
April	5,145,158	6,958,467	8,593,220	13,305,713	10,846,592
May	5,539,186	7,473,214	9,161,882	9,959,638	11,901,287
June	5,187,674	7,289,629	9,081,698	10,496,652	11,781,430
July	5,557,028	7,317,115	8,872,958	11,502,482	11,342,743
August	5,806,369	6,916,638	6,837,976	10,488,861	10,932,234
September	5,545,693	7,097,031	6,274,684	10,303,130	11,401,009
October	6,113,376	7,617,577	7,901,411	10,032,585	12,377,420
November	5,641,805	7,535,142	8,193,609	10,017,997	11,586,837
December	5,927,324	7,771,444	8,563,554	11,545,125	11,825,600
	65,473,323	84,920,225	97,994,900	123,294,317	136,934,439

Average daily production of petroleum in the Mid-Continent field, 1912–1916, in barrels.

Month.	1912	1913	1914	1915	1916
January	159,208	202,296	259,386	259,886	335,493
February	168,808	212,551	258,796	294,216	369,843
March	166,414	216,818	297,635	301,533	381,081
April	171,505	231,949	286,440	443,523	361,553
May	178,683	241,071	295,545	321,279	383,912
June	172,932	242,988	302,724	349,889	392,714
July	179,259	236,036	286,225	371,048	365,895
August	187,302	223,117	220,580	338,351	352,653
September	184,856	236,568	209,156	343,437	380,034
October	197,206	245,728	254,885	323,635	399,272
November	188,060	251,171	273,120	333,934	386,228
December	191,204	250,692	276,243	372,424	381,478
Average	178,889	232,658	268,479	337,793	374,138

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PIPE-LINE RUNS, DELIVERIES, AND STOCKS.

Pipe-line runs and deliveries to trade of petroleum from the Mid-Continent field and stocks at end of each month in 1915 and 1916, in barrels.

Month.	1915			1916		
	Runs.	Deliveries.	Stocks.	Runs.	Deliveries.	Stocks.
Dec. 31, 1914			60,817,694			
January	8,056,449	4,811,459	64,062,684	10,400,281	5,482,385	79,214,313
February	8,238,063	7,151,660	65,149,087	10,725,449	11,453,080	78,486,682
March	9,347,522	8,057,597	66,439,012	11,813,497	12,884,710	77,415,469
April	13,305,713	4,261,578	75,483,147	10,846,592	9,881,072	78,380,989
May	9,959,638	8,296,882	77,145,903	11,901,287	10,576,492	79,705,784
June	10,496,652	7,550,920	80,091,635	11,781,430	10,637,837	80,849,377
July	11,502,482	11,210,116	80,384,001	11,342,743	8,918,902	83,273,218
August	10,488,861	10,436,639	80,436,223	10,932,234	11,658,916	82,546,536
September	10,303,130	11,149,275	79,590,078	11,461,009	12,516,276	81,431,269
October	10,032,685	10,774,529	78,848,234	12,377,420	13,010,817	80,797,872
November	10,017,997	13,828,282	75,037,949	11,586,837	12,501,833	79,882,876
December	11,545,125	12,286,657	74,296,417	11,825,660	14,401,317	77,307,219
	123,294,317	109,815,594		136,934,439	133,923,637	

SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on pages 706–708, which are obtained from reports received directly from the oil producers:

Wells completed in the Mid-Continent field, 1912–1916.

District.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Kansas	536	1,422	1,753	610	3,142	160	260	270	147	370	949	2,016	2,340	1,088	3,624
Oklahoma	4,712	6,965	6,410	3,397	6,086	843	1,308	1,343	885	1,120	5,993	8,851	8,292	4,624	7,583
Central and northern Texas	299	581	497	307	500	124	208	221	198	145	434	799	744	528	683
Northern Louisiana	239	356	302	349	324	62	93	94	89	141	353	519	448	464	530
	5,786	9,321	8,962	4,663	10,052	1,189	1,869	1,928	1,319	1,776	7,729	12,185	11,824	6,704	12,410

[a] Including gas wells.

Oil wells and dry holes drilled in the Mid-Continent field in 1916.

District.	January.		February.		March.		April.		May.		June.		July.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Kansas	140	9	180	17	254	23	296	49	416	47	436	44	397	16
Oklahoma	512	84	458	102	566	136	627	145	750	133	679	106	663	78
Central and northern Texas	34	12	44	8	37	16	54	11	56	13	62	14	41	17
Northern Louisiana	24	11	33	11	40	12	27	8	40	7	32	3	30	10
	710	116	715	138	897	187	1,004	213	1,262	200	1,209	167	1,131	121

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Oil wells and dry holes drilled in the Mid-Continent field in 1916—Continued.

District.	August.		September.		October.		November.		December.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Kansas	251	45	235	42	148	29	239	36	150	13	3,142	370
Oklahoma	527	92	362	74	345	71	286	41	311	58	6,086	1,120
Central and northern Texas	24	9	40	16	31	12	38	8	39	9	500	145
Northern Louisiana	27	19	31	18	17	22	14	7	9	13	324	141
	829	165	668	150	541	134	577	92	509	93	10,052	1,776

Wells completed in the Mid-Continent field, 1912–1916.

Month.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
January	152	488	976	290	710	32	111	211	76	116	207	669	1,260	422	873
February	317	553	921	307	715	78	98	185	94	138	444	715	1,186	457	911
March	335	514	1,067	250	897	64	100	226	76	187	437	660	1,368	362	1,146
April	456	624	1,026	312	1,004	98	77	263	85	213	615	759	1,377	452	1,263
May	496	811	1,113	293	1,262	103	162	246	75	200	653	1,083	1,461	402	1,554
June	576	867	949	297	1,209	120	191	155	99	167	776	1,180	1,176	431	1,410
July	558	880	734	264	1,131	95	237	147	76	121	706	1,207	948	391	1,282
August	567	927	639	307	829	93	176	107	106	165	729	1,186	812	467	1,040
September	532	839	562	261	668	107	139	101	107	150	711	1,062	712	448	867
October	588	881	373	477	541	146	177	87	118	134	822	1,144	556	647	718
November	637	953	269	686	577	158	184	90	217	92	890	1,223	448	1,011	698
December	582	987	333	919	509	95	217	110	190	93	739	1,297	520	1,214	648
	5,786	9,324	8,962	4,663	10,052	1,189	1,869	1,928	1,319	1,776	7,729	12,185	11,824	6,704	12,410

[a] Including gas wells.

Initial daily production of new wells completed in the Mid-Continent field in 1916, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Kansas	2,845	3,875	6,410	9,784	14,429	33,501	28,741	30,569	50,243	35,232	20,402	12,815	248,846
Oklahoma	32,867	56,386	43,347	40,971	63,180	86,181	59,114	35,759	24,753	30,910	21,365	27,062	521,895
Central and northern Texas	2,540	2,784	3,119	4,168	4,809	10,841	9,941	1,927	2,336	1,809	4,303	1,151	49,728
Northern Louisiana	7,715	7,860	11,665	2,965	5,451	4,500	5,005	2,295	4,205	765	2,025	420	54,871
	45,967	70,905	64,541	57,888	87,869	135,023	102,801	70,550	81,537	68,716	48,095	41,448	875,340

Total and average initial daily production of new wells in the Mid-Continent field, 1912–1916, by districts, in barrels.

District.	Total initial production.					Average per well.				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Kansas	7,215	22,467	18,932	11,319	248,846	13.5	15.8	10.8	18.6	79.2
Oklahoma	228,886	334,050	976,244	1,036,170	521,895	48.6	48.0	152.3	305.0	85.8
Central and northern Texas	28,213	57,435	25,003	52,663	49,728	94.3	98.9	50.3	171.5	99.5
Northern Louisiana	84,098	151,955	102,193	198,116	54,871	351.9	426.8	338.4	567.7	169.4
	348,442	565,907	1,122,372	1,298,268	875,340	60.2	60.7	125.2	278.4	87.1

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Total initial daily production of new wells in the Mid-Continent field, 1912–1916, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.
1912	19,283	22,437	24,429	37,573	24,592	22,099	23,971
1913	29,305	35,551	36,189	54,518	59,191	55,466	48,142
1914	38,308	53,507	90,341	73,165	121,193	152,780	95,017
1915	129,224	130,482	106,485	168,780	144,520	127,330	101,961
1916	45,967	70,905	64,541	57,858	87,860	135,023	102,801

Year	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1912	30,153	36,468	38,877	37,573	30,987	348,442	29,037
1913	53,929	41,405	48,436	40,756	63,019	565,907	47,159
1914	104,984	96,098	83,923	75,401	137,675	1,122,372	93,531
1915	73,418	56,150	72,337	80,763	63,629	1,256,098	104,592
1916	70,550	81,537	68,716	48,095	41,448	875,340	72,945

PRICES.

The following table shows the changes in prices of Mid-Continent oil in 1915 and 1916, and the dates on which the changes were made:

Prices of Mid-Continent oil per barrel in 1915 and 1916, by grades.

1915.

Date.	Kansas and Oklahoma.	Healdton, Okla.	Northern Texas.			Northern Louisiana.		
			Corsicana (light), Henrietta, Electra, and Moran.	Powell (heavy).	Thrall and Strawn.	Caddo.	De Soto and Sabine.	Red River.
Jan. 1	$0.55	$0.50	$0.55	$0.55		$0.45–$0.80	$0.80	$0.50
Feb. 2		.30						
Feb. 8	.45							
Feb. 15	.40		.45	.40				
Feb. 18						.45–.70	.70	
Mar. 3							.60	
Mar. 24						.45–.60	.50	
Mar. 26						.35–.60		
May 3					$0.45			
July 13								.45
July 16								(a)
July 20								.40
Aug. 2	.50							
Aug. 4	.55		.55					
Aug. 6			.60		.55			
Aug. 11	.60							
Aug. 13			.65		.60			
Aug. 19	.65							
Aug. 21	.75		.70					
Aug. 26			.75		.65			
Aug. 27						.40–.65	.55	.45
Sept. 11	.80				.70			
Sept. 16			.80		.75	.45–.70	.60	.50
Sept. 22						.50–.75	.65	.55
Sept. 24		.35						
Oct. 6						.55–.80	.70	.60
Oct. 11		.40						
Oct. 25		.45		.45				
Nov. 13	.90							
Nov. 15	1.00	.55	1.00	.55	.95			
Nov. 18						.65–.90	.80	.70
Nov. 20						.75–1.00	.90	.80
Dec. 13	1.10							
Dec. 14	1.20		1.20	.60	1.05			
Dec. 17						.80–1.10	1.00	.85
Dec. 28						.80–1.20	1.10	

a On July 16 the Texas Co. reduced the price of Red River oil to $0.35, advancing it to $0.45 Aug. 28.

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Prices of Mid-Continent oil per barrel in 1915 and 1916, by grades—Continued.

1916.

Date.	Kansas and Oklahoma.	Healdton, Okla.	Northern Texas.			Northern Louisiana.[b]		
			Corsicana (light), Henrietta, Electra, and Moran.	Powell (heavy).	Thrall Strawn, and Yale.[a]	Caddo.	De Soto and Sabine.	Red River.
Jan. 1	$1.20	$0.60	$1.20	$0.60	$1.05	$0.80–$1.20	$1.10	$0.85
Jan. 8		.65		.65				
Jan. 20	1.25							
Jan. 21		.70	1.25	.70				
Jan. 24								.90
Jan. 25						.85–1.25	1.15	
Jan. 26	1.30				1.25			
Jan. 27		.75	1.30	.75	1.30			
Jan. 28						.90–1.30	1.20	.95
Mar. 4	1.40		1.40					
Mar. 8						.90–1.40	1.30	1.00
Mar. 10					1.40			
Mar. 11	1.45							
Mar. 13		.80	1.45	.80	1.45			
Mar. 14	1.55		1.55		1.55			
Mar. 15						.90–1.45	1.35	1.05
Mar. 27						.90–1.55	1.45	
June 16								.90
June 24								.80
July 14			1.45					
July 15						.80–1.55		
July 16								.70
July 24	1.45							
July 25						.70–1.45		
July 26		.70		.70			1.35	
July 27					1.45			
July 29						.65–1.45		.65
July 31		.60		.60				
Aug. 1	1.25		1.35		1.35	.65–1.35	1.25	
Aug. 2		.50	1.25	.50	1.25	.65–1.25	1.15	
Aug. 7	1.15							
Aug. 8			1.15		1.15	.65–1.15	1.05	
Aug. 12	1.05							
Aug. 14		.45	1.05	.45	1.05		.95	
Aug. 15	.95					.65–1.05		
Aug. 16		.40	.95	.40	.95		.85	
Aug. 17						.65–.95		
Aug. 26	.90		.90		.90		.80	
Aug. 29						.65–.90		.60
Nov. 29	1.00		1.00		1.00		.90	
Nov. 30		.45		.45				
Dec. 2						.65–1.00		
Dec. 4								.70
Dec. 12	1.10	.50	1.10	.50	1.10		1.00	
Dec. 14						.75–1.10		
Dec. 15								.80
Dec. 18	1.20		1.20		1.20		1.10	
Dec. 19		.60		.60		.75–1.20		.90
Dec. 23	1.30	.70	1.30	.70				
Dec. 26							1.20	
Dec. 27					1.30	.85–1.30		1.00
Dec. 28	1.40	.75						1.10
Dec. 29			1.40	.75	1.40	.85–1.40	1.30	

[a] Added to list of quotation Nov. 30.

[b] Dates of change in price are those on which quotations by the Standard Oil Co. of Louisiana became effective. Quotations by other purchasers of oil in this field became effective on or near the same date.

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Average monthly price per barrel of Mid-Continent petroleum in 1915 and 1916.

1915.

Month.	Kansas and Oklahoma.	Healdton, Okla.	Northern Texas.			Northern Louisiana.		
			Corsicana (light), Henrietta, Electra, and Moran.	Powell (heavy).	Thrall and Strawn.	Caddo.	De Soto and Sabine.	Red River.
January	$0.55	$0.50	$0.55	$0.50	.....	$0.45–$0.89	$0.80	$0.50
February	.45	.31	.50	.45	.....	.45– .76	.76	.50
March	.40	.30	.45	.40	.....	.41– .67	.58	.50
April	.40	.30	.45	.40	.....	.35– .60	.50	.50
May	.40	.30	.45	.40	$0.45	.35– .60	.50	.50
June	.40	.30	.45	.40	.45	.35– .60	.50	.50
July	.40	.30	.45	.40	.45	.35– .60	.50	.45
August	.63	.30	.64	.40	.57	.36– .61	.51	.41
September	.78	.31	.78	.40	.71	.44– .69	.59	.49
October	.80	.40	.80	.41	.75	.54– .79	.69	.59
November	.91	.50	.91	.40	.86	.63– .88	.78	.63
December	1.12	.58	1.12	.58	1.01	.78– 1.06	.96	.82
Average	.60	.37	.63	.43	.66	.46– .75	.64	.53

1916.

Month.	Kansas and Oklahoma.	Healdton, Okla.	Northern Texas.			Northern Louisiana.		
			Corsicana (light), Henrietta, Electra, and Moran.	Powell (heavy).	Thrall and Strawn.	Caddo.	De Soto and Sabine.	Red River.
January	$1.23	$0.66	$1.23	$0.66	$1.10	$0.82–$1.19	$1.12	$0.87
February	1.30	.75	1.30	.75	1.30	.90– 1.30	1.20	.95
March	1.48	.78	1.48	.78	1.46	.90– 1.42	1.32	1.02
April	1.55	.80	1.55	.80	1.55	.90– 1.55	1.45	1.05
May	1.55	.80	1.55	.80	1.55	.90– 1.55	1.45	1.05
June	1.55	.80	1.55	.80	1.55	.90– 1.55	1.45	.95
July	1.52	.78	1.49	.78	1.53	.82– 1.53	1.43	.74
August	1.04	.45	1.06	.45	1.06	.65– 1.07	.96	.65
September	.90	.40	.90	.40	.90	.65– .90	.80	.60
October	.90	.40	.90	.40	.90	.65– .90	.80	.60
November	.91	.40	.91	.40	.91	.65– .90	.81	.60
December	1.15	.56	1.15	.56	1.14	.72– 1.12	1.04	.82
Average	1.26	.63	1.25	.63	1.24	.79– 1.25	1.15	.82

KANSAS.

GENERAL STATEMENT.

More petroleum was produced in Kansas in 1916 than in any other year in the history of the local industry, which dates from the discovery of oil in commercial quantities near Paola, Miami County, in 1889. The output in 1916, which amounted to 8,738,077 barrels, was greater by 5,914,590 barrels, or 209 per cent, than that in 1915. This remarkable increase was obtained almost wholly from Butler County, and consisted of flush production from the prolific Augusta and Eldorado fields, which came to the front in the closing months of 1915. As a consequence of this increase Kansas advanced from tenth to sixth rank among the States contributing to the petroleum supply of the country, its output in 1916 amounting to nearly 3 per cent of the total output, compared with 1 per cent in 1915.

The average price received at the wells for this oil was $1.18 a barrel, and the total market value of the output was $10,339,958, a gain of

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58 cents in average unit price and of $8,637,067, or 507 per cent, in total market value, compared with $1,702,891 in 1915.

The success of operations in Butler County and the advancing market in the early part of the year, as well as again near its close, resulted in an extensive wildcat campaign that included practically every county in central and eastern Kansas in its scope and that stimulated the quest for extensions and for deeper sands throughout the old areas of oil production in the State.

DEVELOPMENT.

The stimulus provided by increasing demands for oil, by large areas of proved but undrilled oil land, and by practically unlimited areas of untested and not wholly unfavorable territory resulted in the completion of 3,624 wells in Kansas in 1916, compared with only 1,088 wells in 1915. Of these, 3,142, or 87 per cent, were oil wells credited with an average yield of 79 barrels each the first day of productive life, 112 were gassers, and 370, an average of 1 in 10, were failures.

The activity recorded by these figures was distributed over 25 counties, but was centered in Butler County in and about the borders of the Augusta and Eldorado fields. In this county alone 835 successful oil wells, 35 gas wells, and 132 dry holes were completed. The average initial daily capacity of the new oil wells was 256 barrels each.

The producing area of each of these fields was greatly extended. At the end of 1916 there were in the Eldorado field about 600 producing wells, with an output estimated at 15,000 barrels, and in the Augusta field about 200 producing oil wells, with an estimated production of 45,000 barrels. The discovery of oil in commercial quantities in test wells completed late in 1916 near Towanda, 5 miles west of Eldorado, near Potwin, 12 miles northwest of Eldorado, and near Douglas, 6 miles south of Augusta, was accepted as evidence that other important pools would result from development work in 1917. Prior to April the only outlet to market for the production of these pools was by railway tank cars. Early in April the Prairie Pipe Line Co. completed an 8-inch extension of its trunk line from Neodesha to Augusta, a distance of 84 miles, and extended a 4-inch lateral to Eldorado. These lines proved inadequate to handle the production and in the midsummer months many wells in these fields were pinched in until increased facilities for handling the output of oil could be provided.

The success of drilling in Butler County led to extensive wildcat drilling in adjacent counties. Interest in this type of operations was aroused at times during 1916 by favorable showings of oil or gas in tests drilled near Virgil and Eureka, and east of Beaumont, in Greenwood County; near Hunnewell, in Sumner County; and near Winfield, in Cowley County. In the last-named county one well completed in July, in the NW. ¼ sec. 6, T. 31 S., R. 3 E., about 8 miles north of Winfield, was credited with an initial capacity of 90 barrels of oil from a sand reached at a reported depth of 2,830 feet. Additional tests near the oil well completed in 1914 at Dexter, in sec. 24, T. 33 S., R. 6 E., 25 miles southeast of this well, were failures.

In the old shallow-sand fields of eastern Kansas drilling activity was much in excess of that in 1915. Interest in operations in the town-lot development at Paola, Miami County, the pioneer oil town of the State, as well as in the acreage development 6 miles west of that town that came into prominence in 1915, was well sustained

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throughout 1916. The area about Wellsville, in Franklin County, rewarded increased drilling with a number of excellent wells, which increased the average initial capacity of all new wells in this county from 8 barrels each in 1915 to 11 barrels each in 1916. New production was found in the vicinity of Mound Valley, Labette County, southeast of the old Cherryvale district.

UNSUCCESSFUL TESTS.

Deep tests, of interest on account of their location, though unsuccessful from the standpoint of production of oil or gas, were completed in Kansas in 1916, as follows:

Chase County.—July—Will Roeser and others; in sec. 13, T. 18 S., R. 8 E.; depth, 2,446 feet. Wichita Oil & Gas Co.; in sec. 2, T. 20 S., R. 7 E.; depth, 1,945 feet.

September—Watchorn and others; on the Patton farm, in sec. 18, T. 18 S., R. 8 E.; depth, 2,480 feet.

Marion County.—August—Central Refining Co.; on the Mehill farm, in sec. 11, T. 20 S., R. 4 E., near Florence.

September—Roxana Petroleum Co.; on the Clothier farm, in sec. 22, T. 21 S., R. 5 E.; depth, 1,800 feet.

Elk County.—September—Farsh Oil & Gas Co.; on the Bascom farm, in sec. 9, T. 29 S., R. 9 E.; depth, 2,262 feet. Phœnix Refining Co.; on the Mullindore farm, in sec. 20, T. 29 S., R. 8 E.; depth, 2,250 feet.

Lyons County.—September—McMan Oil Co.; on the Pixlee farm, in sec. 34, T. 21 S., R. 10 E.; depth, 2,345 feet. (Oil showing reported at 2,160 feet.)

October—Barriclow and others; on the McAuley farm, in sec. 30, T. 21 S., R. 12 E.; depth, 2,000 feet.

Woodson County.—September—Labette Oil Co.; on the Hill farm, sec. 32, T. 26 S., R. 15 E.; depth, 1,320 feet.

October—Wichita Natural Gas Co.; on the Metzger farm, in sec. 26, T. 25 S., R. 15 E.; depth, 1,550 feet. Mid-Continental Oil & Gas Co.; on the Dyer farm, in sec. 2, T. 26 S., R. 13 E.; depth, 1,530 feet.

Wilson County.—October—Knox Bros.; on the Thompson farm, in sec. 5, T. 27 S., R. 14 E.; depth, 1,400 feet.

MARKETED PRODUCTION.

Petroleum marketed in Kansas, 1915 and 1916, in barrels.

Month.	Runs to local refineries.	Other runs and field fuel.	Rail shipments not included in pipe-line runs.	Total.
1915.				
January	35,483	207,941	2,182	245,606
February	30,851	175,453	1,107	207,411
March	27,089	197,303	1,811	226,183
April	20,579	187,623	971	209,173
May	28,034	182,382	743	211,159
June	32,386	185,260	192	217,838
July	27,576	210,608	1,032	239,216
August	25,372	221,033	624	247,029
September	22,025	224,410	6,313	252,748
October	22,268	230,217	7,009	259,494
November	21,421	234,477	7,057	262,955
December	22,938	216,529	5,208	244,675
	316,002	2,473,236	34,249	2,823,487
1916.				
January	19,437	177,635	276	197,348
February	20,584	263,758	384	284,726
March	21,920	331,102	671	353,693
April	20,686	420,427	309	441,422
May	22,836	610,142	698	633,726
June	21,879	810,689	2,072	834,640
July	20,782	674,317	10,277	705,376
August	21,261	546,306	77,100	644,667
September	20,535	871,590	59,391	951,516
October	22,399	1,163,002	75,184	1,260,585
November	34,500	1,112,136	65,823	1,212,459
December	29,408	1,131,792	56,719	1,217,919
	276,277	8,112,896	348,904	8,738,077

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SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the tables following are compiled from trade-journal sources and differ somewhat from those on page 707, obtained from reports received directly from the oil producers.

Wells completed in Kansas, 1912–1916.

County.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Allen	50	154	175	49	314	6	11	10	3	8	58	171	193	65	326
Anderson	.....	.....	1	.....	.....	.....	.....	.....	4	.....	.....	.....	1	4	.....
Bourbon	.....	.....	1	.....	2	.....	.....	.....	.....	1	.....	.....	1	.....	3
Butler	.....	.....	5	22	835	.....	.....	.....	4	132	.....	.....	29	60	1,002
Chase	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1
Chautauqua	182	311	308	112	441	28	77	38	26	52	222	442	376	164	513
Coffey	.....	.....	5	3	4	.....	.....	1	.....	.....	.....	.....	7	3	4
Cowley	.....	.....	3	2	3	.....	.....	8	4	14	.....	.....	17	18	20
Elk	.....	.....	.....	.....	11	.....	.....	3	2	7	.....	.....	3	5	19
Ford	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....
Franklin	18	54	163	71	234	.....	3	30	22	15	18	58	225	114	252
Greenwood	.....	.....	.....	.....	2	.....	.....	.....	.....	6	.....	.....	.....	1	8
Labette	2	.....	8	19	14	.....	.....	18	3	.....	2	3	54	29	14
Linn	.....	.....	2	.....	1	.....	.....	.....	.....	.....	.....	.....	2	.....	1
Lyon	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	2
McPherson	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1
Miami	.....	.....	131	33	217	.....	.....	42	15	55	.....	.....	186	52	274
Montgomery	202	602	691	201	777	47	92	75	49	48	365	867	903	379	860
Morris	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1
Neosho	62	257	221	92	235	23	27	19	9	8	115	316	263	144	249
Osage	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1
Ottawa	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1
Pottawatomie	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1
Sedgwick	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	2
Sumner	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	1
Wilson	18	40	27	6	45	52	45	20	4	2	156	139	59	23	50
Woodson	1	2	12	.....	7	3	3	2	2	11	7	5	14	25	18
Miscellaneous	1	2	.....	.....	.....	1	2	4	.....	.....	6	15	7	.....	.....
	536	1,422	1,753	610	3,142	160	260	270	147	370	949	2,016	2,340	1,088	3,624

[a] Including gas wells.

Oil wells and dry holes drilled in Kansas in 1916.

County.	January.		February.		March.		April.		May.		June.		July.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Allen	11	2	15	.....	33	.....	42	2	46	1	49	2	57	.....
Bourbon	.....	.....	.....	.....	.....	.....	.....	.....	2	1	.....	.....	.....	.....
Butler	9	.....	15	3	53	9	57	15	114	17	111	15	70	2
Chase	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Chautauqua	31	2	25	5	50	2	43	4	46	5	57	11	77	5
Coffey	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	1	.....
Cowley	.....	.....	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	2	2
Elk	.....	.....	.....	.....	2	.....	1	.....	4	.....	3	.....	.....	.....
Franklin	12	.....	11	.....	17	.....	21	.....	34	4	38	2	48	2
Greenwood	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....
Labette	.....	.....	4	.....	.....	.....	2	.....	5	.....	3	.....	.....	.....
Linn	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Lyon	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
McPherson	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Miami	9	2	18	.....	22	3	24	15	30	9	31	8	26	2
Montgomery	59	3	72	4	55	9	71	8	88	5	109	6	75	2
Morris	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Neosho	9	.....	19	1	21	.....	31	1	30	5	27	.....	41	.....
Osage	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ottawa	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pottawatomie	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Sedgwick	.....	.....	.....	1	.....	.....	.....	1	.....	.....	.....	.....	.....	.....
Sumner	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Wilson	.....	.....	.....	.....	.....	.....	4	2	15	.....	6	.....	.....	.....
Woodson	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	2	.....	.....	.....
	140	9	180	17	254	23	296	49	416	47	436	44	397	16

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Oil wells and dry holes drilled in Kansas in 1916—Continued.

County.	August.		September.		October.		November.		December.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Allen	11		7	1	8		16		19		314	8
Bourbon											2	1
Butler	107	18	94	17	81	7	74	20	50	9	835	132
Chase												1
Chautauqua	36	4	26	10	8	2	30	2	12		441	52
Coffey	1						1				4	
Cowley		4		2		1	1	2			3	14
Elk		3		2	1	1		1			11	7
Franklin	11	3	8	1	10	2	20	1	4		234	15
Greenwood		1		1	2	1		1		1	2	6
Labette											14	
Linn											1	
Lyon						2						2
McPherson		1										1
Miami	13	7	10	1	16	2	16	6	8		217	55
Montgomery	62	4	75	5	15		59		37	2	777	48
Morris										1		1
Neosho	10		9	1	9		12		17		235	8
Osage								1				1
Ottawa						1						1
Pottawatomie								1				1
Sedgwick												2
Sumner						1						1
Wilson			4		4		9		3		45	2
Woodson			2	1		9	1	1			7	11
	251	45	235	42	148	29	239	36	150	13	3,142	370

Wells completed in Kansas, 1912–1916.

Month.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
January	4	41	207	47	140	2	6	31	9	9	9	75	266	88	156
February	11	69	194	38	180	7	9	18	24	17	27	107	228	94	209
March	10	61	199	15	254	9	12	32	1	23	27	88	251	23	293
April	23	62	191	10	296	9	13	42	5	49	46	96	254	33	352
May	37	97	230	7	416	12	29	30	7	47	75	172	284	24	477
June	46	128	203	7	436	8	30	10	4	44	72	190	228	28	489
July	60	147	153	12	397	7	31	21	12	16	77	202	201	57	423
August	80	155	115	27	251	10	20	9	14	45	115	207	144	78	305
September	56	133	95	26	235	18	23	17	6	42	106	185	133	79	287
October	63	147	61	68	148	29	32	15	18	29	138	209	119	91	179
November	81	184	50	131	239	34	24	20	26	36	155	236	114	206	379
December	65	194	55	222	150	15	31	25	26	13	102	249	118	287	175
	536	1,422	1,753	610	3,142	160	260	270	147	370	949	2,016	2,340	1,088	3,624

[a] Including gas wells.

Initial daily production of new wells completed in Kansas in 1916, in barrels.

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Allen	130	150	435	498	582	475	817	141	73	85	220	165	3,771
Bourbon					20								20
Butler	645	1,380	3,125	5,920	9,835	28,794	23,280	28,645	48,260	34,184	18,250	11,315	213,633
Chautauqua	705	775	1,000	1,095	1,195	1,415	1,836	553	570	205	385	360	10,088
Coffey			10				10	10			10		40
Cowley							90				50		140
Elk			20	20	40	65				14			159
Franklin	130	130	205	305	430	338	585	140	85	86	152	80	2,666
Greenwood										18			18
Labette		20		10	40	15							85
Linn		10											10
Miami	490	504	515	500	537	324	265	134	170	160	405	195	4,199
Montgomery	620	691	795	841	1,212	1,535	1,259	821	905	365	695	465	10,204
Neosho	125	215	305	550	433	475	605	125	100	95	160	180	3,368
Wilson				45	80	50			45	20	70	55	365
Woodson					25	15			35		5		80
	2,845	3,875	6,410	9,784	14,429	23,501	28,741	30,569	50,243	35,232	20,402	12,815	248,846

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Total and average initial daily production of new wells in Kansas, 1912–1916, by counties, in barrels.

County.	Total initial production.					Average per well.				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Allen	632	2,960	1,896	500	3,771	12.6	19.2	10.8	10.2	12.0
Anderson	.....	.....	10	.....	.....	.....	.....	10.0	.....	.....
Bourbon	.....	.....	5	.....	20	.....	.....	5.0	.....	10.0
Butler	.....	.....	47	3,320	213,633	.....	.....	9.4	15.1	255.8
Chautauqua	2,963	7,358	5,379	2,515	10,088	16.3	23.7	17.5	22.5	22.9
Coffey	.....	.....	45	20	40	.....	.....	9.0	6.7	10.0
Cowley	.....	.....	150	55	140	.....	.....	50.0	27.5	46.7
Elk	.....	.....	.....	.....	159	.....	.....	.....	.....	14.5
Franklin	155	748	1,360	620	2,666	8.6	13.9	8.3	8.7	11.4
Greenwood	.....	.....	.....	.....	18	.....	.....	.....	.....	9.0
Labette	15	.....	32	105	85	7.5	.....	4.0	5.5	6.1
Linn	.....	.....	30	.....	10	.....	.....	15.0	.....	10.0
Miami	.....	.....	920	462	4,199	.....	.....	7.0	14.0	19.4
Montgomery	2,522	5,871	6,262	2,505	10,204	12.5	9.8	9.1	12.5	13.1
Neosho	603	5,168	2,414	1,182	3,368	11.2	20.1	10.9	12.8	14.3
Wilson	255	342	268	35	365	14.2	8.6	9.9	5.8	8.1
Woodson	5	13	114	.....	80	5.0	6.5	9.5	.....	11.4
Miscellaneous	5	7	.....	.....	.....	5.0	3.5	.....	.....	.....
	7,245	22,467	18,932	11,319	248,846	13.5	15.8	10.8	18.6	79.2

Total initial daily production of new wells in Kansas, 1912–1916, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1912	65	173	213	390	352	714	834	940	507	842	1,185	1,030	7,245	604
1913	860	1,065	1,003	1,897	1,518	1,918	1,945	2,250	2,283	2,501	2,857	2,340	22,467	1,872
1914	2,077	2,196	1,950	2,083	2,411	2,178	1,820	1,395	1,006	700	501	615	18,932	1,578
1915	843	974	230	105	110	130	225	530	370	790	1,927	5,085	11,319	943
1916	2,845	3,875	6,410	9,784	14,429	33,501	28,741	30,569	50,243	35,232	20,402	12,815	248,846	20,737

OKLAHOMA.

GENERAL STATEMENT.

The premier position as contributor to the petroleum supply of the United States, assumed by Oklahoma in 1915, was maintained in 1916, the output from this State being more than 16,000,000 barrels in excess of that from California, its closest competitor for first honors. The output in 1916 was 107,071,715 barrels, a quantity 9,156,472 barrels, or 9 per cent, greater than in 1915. This output establishes a new record for petroleum production in Oklahoma that is more than 7,000,000 barrels in excess of the maximum production marketed from any other State in a single year. Prior to 1915 the record for petroleum marketed was held by California, the output of which State in 1914 was in excess of 99,000,000 barrels. The output from Oklahoma in 1916 constituted nearly 36 per cent of the total output of petroleum in the entire country in that year, a gain for the State of about 1 per cent in relative importance compared with 1915.

Credit for the increase noted, which represents a daily excess of approximately 25,000 barrels over the output in 1915, was well distributed among the productive fields of the State, other than Cushing. The output of the Cushing district was 9,168,656 barrels, or nearly 19 per cent less than in 1915, its average daily deficit in output compared with 1915 amounting to about 25,000 barrels, which other

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fields were forced to make good before net gains were possible. In general it may be said that the increase in 1916 was in direct response to improved market conditions resulting from the decline in output of the Cushing district and the subsequent demand for oil from other fields.

Although Glenn, the Osage, and many other lesser districts shared in the credit for this increase, the most notable gain in output compared with 1915 was in the Healdton district, Carter County, which increased its yield from 4,818,835 barrels to 13,600,931 barrels, a net gain of 8,782,096 barrels, or 182 per cent, in 1916—a gain less by nearly 400,000 barrels than the net loss in yield from Cushing.

So prompt and hearty was the response from other oil fields in Oklahoma, once the menace of Cushing's flush production had passed, and so successful was the effort to develop a new pool at Shamrock, a few miles south of Cushing, in Creek County, that prices for Oklahoma-Kansas grades of oil, which had advanced from $1.20 a barrel on January 1 to $1.45 on July 24, began on August 1 a decline that forced quotations to 90 cents a barrel on August 26, and caused a decided repression in drilling throughout the State. This action served to prevent further declines, and on November 29, a reverse movement of prices began that advanced quotations to $1.40 a barrel before the end of the year.

The average price received at the wells for all grades of crude oil marketed in Oklahoma in 1916 was $1.20 a barrel, and the market value of the entire output was $128,463,805, a gain of 62 cents, or 107 per cent, in average unit price and of $71,757,672, or 127 per cent, in gross market value compared with 1915. Oklahoma's share of the total receipts from the sale of crude petroleum at wells in the United States in 1916 was nearly 39 per cent, a share larger by nearly 23 per cent than that of California, the second largest beneficiary.

DEVELOPMENT.

Although activity in drilling in Oklahoma in 1916 was less than in either 1913 or 1914, it was 65 per cent greater than in 1915. A total of 7,583 wells were completed, of which 6,086, or 80 per cent, were oil wells credited with an average yield of 86 barrels of oil each the first day of productive life; 377, or 5 per cent, were gas wells; and 1,120, an average of about 1 in every 7, were failures.

NORTHEASTERN OKLAHOMA.

Cherokee district.—Developments in the shallow-sand area in Nowata County were enlivened in May by the completion on the Gilmore farm, sec. 9, T. 28 N., R. 14 E., of a 500-barrel oil well in territory that for months had failed to furnish wells with initial capacities in excess of 50 barrels each. Subsequent drilling in this locality developed a number of other wells that produced in excess of 100 barrels each the first 24 hours after completion. Outside this locality interest was well sustained in the territory adjacent to Chelsea, in northern Rogers County, where a large number of wells of more than average initial capacity were completed near the center of T. 24 N., R. 17 E.

In the deep-sand area in Washington, northern Tulsa, and western Rogers counties no developments of consequence resulted from the

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active drilling campaign in 1916. New oil wells in this area averaged 17 barrels each the first day of productive life. The Vera pool, discovered in 1915 in the southeastern corner of Washington County, was fully drilled during 1916. Several gas wells of large capacity were completed near Ochelata just east of the Osage boundary.

An extension of the Claremore pool in Rogers County was demonstrated at the end of the year by the completion, as a 30-barrel oil well, of a test on the Taylor farm, in sec. 3, T. 21 N., R. 15 E. In northern Tulsa County the Day pool, 6 miles northeast of Tulsa, furnished a number of creditable producers.

Osage district.—The quantity of petroleum marketed from the Osage Indian Reservation in 1916 was 8,852,843 barrels, a gain of 248,454 barrels, or 3 per cent, over 1915. The revenue accruing to the Indians from the sale of this oil was $1,730,674, a gain of $1,101,135, or 174 per cent, over that obtained in 1915. This gain was due in part to the higher market value of oil in 1916 and in part to the larger royalties exacted from operators on oil lands within the reservation subsequent to March 3, the date of termination of the old Foster lease.

To dispose of the acreage held by companies in excess of the maximum of 4,800 acres prescribed by the regulations that became effective on this date, an auction was held at Pawhuska on April 20. In all 108 properties were offered, of which number 93 were sold. On these properties were 391 wells of an estimated daily capacity of 4,802 barrels of oil and equipment valued at $718,550. The total bonus bid was $2,269,400, which, added to the appraised value of equipment, gives $2,987,950 as the total cost of the properties, an average price of $622 per barrel of production.

The most important development of the Osage in 1916 was the opening by the Tidal Oil Co. of a relatively small but prolific pool of oil in secs. 8 and 9, T. 23 N., R. 8 E., about 5 miles northwest of Hominy. Activity in the older districts was greater than in 1915, but resulted in no developments of consequence.

Pawnee County.—Aside from a town-lot development at Cleveland that furnished a number of good wells, interest in Pawnee County in 1916 was centered in operations at Jennings, where a small pool of oil was opened in May on the Reinhart farm, in sec. 22, T. 20 N., R. 7 E. In the northwestern part of Pawnee County a few gas wells of fair capacity were completed southeast of Otoe.

Kay County.—Operations in the Ponca City and Newkirk fields were of a routine character and attracted little attention. Chief interest in this county was centered in the results of efforts to develop the Blackwell pool, 8 miles northeast of Blackwell, which came into prominence in 1915. The depth of the oil pay—in excess of 3,000 feet—the presence of gas in great volume in shallower sands, and the hardness of the strata seriously retarded drilling, and during 1916 only 7 wells were completed in the new field. These, however, proved extensions to the south and west approximately 2 miles from the discovery wells in sec. 32, T. 29 N., R. 1 E.

Noble County.—The discovery in February of natural gas at shallow depths in a wildcat test drilled by the Mid-Co. Petroleum Co. on the Hoover farm, sec. 22, T. 23 N., R. 2 W., 20 miles west of any other known oil or gas field, attracted considerable attention and resulted in the starting of a number of other tests when it was found

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that a broad anticlinal fold existed in that locality. The encountering in September of oil showings in the Hoover test at a reported depth of 2,083 feet further stimulated drilling in this locality, but to the end of the year no conclusive test of the oil possibilities of the Billings anticline had been made.

Garfield County.—Interest in the tests near Billings, Noble County, was diverted still further to the southwest in September by the discovery by the Sinclair Oil & Gas Co. of oil in commercial quantities at a reported depth of 1,130 feet on the Hoy farm, in sec. 25, T. 22 N., R. 4 W., on what was later designated the Garber anticline. The high gravity of the oil in this well, reported to be 45.7° Baumé, and the moderate depth at which it was encountered provided an incentive for prompt development, and a number of additional wells were drilling in the locality at the end of 1916. Deeper drilling of the discovery well failed to increase its output, which at the end of the year was estimated to be holding steadily at 50 barrels a day.

Payne County.—The deep-sand territory in the immediate vicinity of Yale received considerable attention, and a number of good wells were completed in secs. 6, 7, and 18, T. 19 N., R. 6 E. The producing limits of the pool were extended westward into sections 13 and 14 of the adjoining township. A prolific gas pool was opened near Ingalls, in secs. 27, 33, and 34, T. 19 N., R. 4 E., in which one well, completed in October, demonstrated the presence of oil in commercial quantities at a depth of 3,685 feet. Considerable gas and relatively small quantities of oil were found in wells in the southeastern part of T. 18 N., R. 6 E., near the town of Cushing.

Creek County.—Aside from the development in the early part of 1916 of a number of prolific wells in a sand found about 75 feet below the Bartlesville sand in the south pool near Drumright, operations in the Cushing district itself were chiefly restricted to the drilling of interior wells, the initial capacities of which averaged considerably less than those of the wells completed in 1915.

Efforts to extend materially the producing area of either the north or the south pool were unsuccessful. Primary interest in western Creek County was centered in Shamrock pool, about 4 miles south of the south Cushing pool, which late in 1915 gave evidence of development into a prolific source of production from the Layton sand. Interest in this development was heightened in the early part of 1916 by the discovery of oil in the deeper-lying Bartlesville sand in the northern part of this pool, and the subsequent completion of many wells of large capacity in this sand. In the southern end of the Shamrock pool oil was obtained only from the Layton sand. A feature of the development in the Shamrock pool was the large volume of gas encountered in practically every well. At the end of 1916 the Shamrock pool covered all or parts of secs. 27, 33, and 34, T. 17 N., R. 7 E., and secs. 2, 3, 4, 8, 9, and 15 of the adjoining township to the south.

Outside the Glenn pool and its various subsidiary pools, which supported an increased activity in 1916, wildcat drilling was the feature of development in eastern and southern Creek County. Efforts to discover production near Mannford in the northern part of the county were unsuccessful. Near Stroud, Depew, and Bristow to the south, dry holes and gas wells of fair capacity were the only rewards.

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Tulsa County.—Drilling in the Jenks, Bixby, and Leonard pools in southern Tulsa County was decidedly active in 1916, and a number of exceptionally good wells were completed in each of these pools.

Wagoner County.—As a consequence of active development in 1916 a prolific pool of high-grade oil was developed at Stone Bluff in northwestern Wagoner County. As ultimately developed, the area of the pool was little more than 500 acres, lying almost entirely in sec. 5, T. 16 N., R. 15 E., though extending slightly into secs. 4 and 6 of the same township. Outside this pool, which was fully drilled in the course of the year, revived activity in the Coweta and Broken Arrow pools to the north resulted in the completion of many wells, some of which demonstrated slight extensions of producing territory.

Okmulgee County.—Slight additions to producing territory in the Morris, Bald Hill, and Tiger Flats pools and the discovery of new pools of small extent in sec. 12, T. 15 N., R. 11 E., designated the Russell pool, and in sec. 28, T. 16 N., R. 12 E., south of Mounds, comprise the most significant results of drilling in Okmulgee County in 1916.

Muskogee County.—The discovery of a small pool of oil on the Cherry farm, in sec. 17, T. 14 N., R. 16 E., 2 miles west of the Boynton pool, and the unsuccessful effort to extend the Boynton pool southward into sec. 34, T. 14 N., R. 16 E., following the completion there of one productive oil well in March, were the principal events of interest to the crude-oil industry in western Muskogee County in 1916. In eastern part of the county a gas pool of promise was opened in sec. 33, T. 14 N., R. 19 E., 8 miles southeast of Muskogee.

EAST-CENTRAL OKLAHOMA.

Okfuskee County.—Continued efforts to develop an important pool of oil in Okfuskee County met disappointment, many tests in the vicinity of the Prairie Oil & Gas Co.'s small oil well in sec. 8, T. 12 N., R. 7 E., near Paden, failing to obtain even a showing of oil. In the northeastern part of the county a "spotted" pool of little consequence was developed as a western extension of the Tiger Flats district, in southern Okmulgee County, in secs. 12, 22, and 27, T. 12 N., R. 11 E.

McIntosh County.—The quest for oil in McIntosh County in 1916 resulted in the completion of a number of tests in various parts of the county that either yielded gas or were total failures. At the end of the year the small pool in sec. 6, T. 11 N., R. 14 E., remained the only source of oil in commercial quantities in the county.

Hughes County.—The results of development work in Hughes County in 1916 include the discovery of a large volume of gas at a depth of 2,972 feet in a test drilled by the Roxana Petroleum Co., in sec. 16, T. 8 N., R. 11 E., about 15 miles northeast of Holdenville, where there was a brief oil excitement in 1915.

Pittsburg County.—What was reported to be the deepest well in Oklahoma was completed as a barren test in January by the Gypsy Oil Co., in sec. 6, T. 6 N., R. 14 E., near McAlester. The reported depth of the well was 4,303 feet. Near Hartshorne, southeast of McAlester, encouraging showings of oil were reported in September at depths of 190 and 278 feet in a wildcat test drilled by the Ti Oil & Gas Co.

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Haskell County.—In sec. 1, T. 7 N., R. 19 E., a flow of gas estimated at 18,000,000 cubic feet a day was reported to have been encountered in March at a depth of 1,440 feet in a test being drilled by the Quinton Oil & Gas Co.

Sequoyah County.—A showing of gas estimated at 1,500,000 cubic feet a day was reported to have been encountered in June at a depth of 1,100 feet in a test drilled by the Gladys Belle Oil Co. in sec. 24, T. 12 N., R. 23 E., near Vian.

Pottawatomie County.—The discovery in February at a depth of 2,945 feet of a large volume of gas and a little oil in a wildcat test drilled in sec. 18, T. 7 N., R. 5 E., by the Maud Oil & Gas Co. aroused much interest in the possibilities of oil production in a locality only 40 miles southeast of Oklahoma City. Additional drilling was begun in the locality, but to the end of the year the possibilities of the pool had not been demonstrated.

Lincoln County.—A gas well completed by the Roxana Petroleum Co. in October in sec. 30, T. 17 N., R. 3 E., and credited with an initial capacity of 25,000,000 cubic feet of gas was the only discovery of importance in Lincoln County in 1916.

SOUTHERN OKLAHOMA.

Carter County.—Aside from the large increase in the production of petroleum already discussed, the results of drilling in the Healdton field in 1916 include the extension of the producing area to the northwest into the northern part of sec. 31, and the southern part of sec. 30, T. 3 S., R. 3 W., and to the southeast from the prolific gas area in sec. 15, T. 4 S., R. 3 W., into secs. 13, 14, 22, 23, and 24 of the same township.

In the Fox district to the north, where a prolific gas well was drilled by the Gypsy Oil Co. in 1915, in sec. 28, T. 2 S., R. 3 W., development work was slow, but the results obtained were most encouraging. Gas from the discovery well was utilized as fuel for the drilling of additional wells and was piped to Ardmore to eke out the failing supply from the old Wheeler district. Only two wells were completed during the year—No. 1 of Phillips & Franklin, in sec. 29, west of the Gypsy gasser, was finished in October as a gas well with an initial capacity estimated at 45,000,000 cubic feet a day; and No. 1 of the McMan-Savoy Oil Co., in sec. 20, northwest of the Gypsy gasser, was finished in September as an oil well with an initial capacity of about 60 barrels a day. The second well of the Gypsy Oil Co., in section 28, begun in January, remained uncompleted at the end of 1916. Late in December this well was drilled into a prolific gas sand encountered at a depth of about 2,080 feet, and drilling was temporarily suspended.

To the east of the Fox district, in sec. 7, T. 2 S., R. 2 W., encouraging showings of oil were obtained in a well drilled near Graham by the Oklahoma-Louisiana Oil Co.

Marketing facilities in the Healdton field were inadequate to care for the production available and field storage increased steadily during the year.

Stephens County.—Further than the completion of additional gas wells in the Loco and Duncan districts the active drilling campaign in 1916 in Stephens County resulted in no significant developments.

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Deep barren tests were completed in sec. 25, T. 1 N., R. 6 W., and in in sec. 26, T. 2 S., R. 7 W. Oil showings and gas in fair volume were found at a depth of 735 feet in a test drilled by the Santa Fe Railway Co. in sec. 2, T. 2 N., R. 5 W. At the end of the year interest was centered on tests in secs. 9 and 13, T. 2 S., R. 4 W., in advance to the west of the prolific gas field at Fox, in Carter County.

Marshall County.—Following upon the discovery of small quantities of exceptionally high-grade oil in a test drilled by the Ardmill Oil Co. in sec. 17, T. 5 S., R. 5 E., a number of other tests were started in various parts of Marshall County in 1916.

Pontotoc County.—Aside from encouraging showings of oil in tests near Francis, about 12 miles west of the Allen pool, and near Steedman, about 6 miles southwest of it, nothing of consequence was developed in Pontotoc County.

Grady, McClain, and Caddo counties.—The discovery of oil in small quantities in wildcat wells near Blanchard, Alex, and Cement in the latter part of 1916 aroused much interest in the oil possibilities of Grady, western McClain, and eastern Caddo counties.

Comanche County.—The shallow-sand territory about Lawton supported a fair activity throughout the year and many wells of small capacity were completed in the southern part of T. 2 S., R. 11 W. Oil from this field was marketed to the Lawton Refining Co., at Lawton, through a pipe line completed in May.

Garvin County.—Wildcat operations in Garvin County in 1916 resulted in the completion of barren tests in sec. 18, T. 2 N., R. 3 E., at 1,700 feet, and in sec. 33, T. 2 N., R. 3 W., at 2,003 feet.

Tillman County.—Near Grandfield a deep test drilled by the Grandfield Oil & Gas Co. in sec. 9, T. 4 S., R. 15 W., was abandoned barren in November at a depth of 2,425 feet.

Bryan County.—Two barren tests were completed in 1916 near Durant, in Bryan County, one at a reported depth of 1,585 feet, in sec. 21, T. 6 S., R. 8 E., the other at 1,500 feet, in sec. 9, T. 7 S., R. 9 E.

Jefferson County.—Efforts to find a western extension of the Healdton pool into northeastern Jefferson County were disappointing, several barren tests being completed in the southeastern part of T. 3 S., R. 4 W., during the year.

Love County.—Unsuccessful tests were completed in Love County in 1916 as follows:

August—C. E. Burford and others; in sec. 12, T. 6 S., R. 2 W.; depth, 2,003 feet.
September—Ed Sewell and others; in sec. 33, T. 7 S., R. 1 W.; depth, 1,514 feet.
October—Oklahoma-Texas Oil Co.; in sec. 8, T. 7 S., R. 2 W.; depth, 2,415 feet.
November—Life Stake Petroleum Co.; in sec. 35, T. 6 S., R. 2 E.; depth, 3,200 feet.

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MARKETED PRODUCTION.

Petroleum marketed in Oklahoma in 1915 and 1916, in barrels.

Month.	Glenn.	Cushing.	Healdton.[a]	Other.	Total.
1915.					
January	464,627	3,395,637	233,389	2,263,157	6,356,810
February	421,922	3,477,229	102,043	2,552,509	6,553,703
March	459,546	4,169,535	93,759	2,706,095	7,428,935
April	455,184	8,092,059	238,591	2,464,989	11,250,823
May	508,786	4,200,234	190,446	2,854,497	7,762,963
June	462,224	4,866,060	306,820	2,728,038	8,363,142
July	551,222	4,407,729	408,050	3,746,459	9,113,460
August	555,514	3,712,734	378,099	3,320,413	7,966,760
September	518,546	3,789,488	431,687	3,134,428	7,874,149
October	534,608	3,197,077	550,766	3,561,007	7,843,458
November	520,012	2,932,428	901,725	3,569,701	7,923,866
December	541,437	2,830,494	983,460	5,121,783	9,477,174
	5,993,628	49,079,704	4,818,835	38,023,076	97,915,243
1916.					
January	528,265	2,664,713	1,128,671	4,119,580	8,441,229
February	614,390	2,819,033	1,280,485	4,049,330	8,763,238
March	838,580	3,060,818	1,448,646	4,283,694	9,631,738
April	562,855	2,769,112	1,401,251	3,888,215	8,621,433
May	657,389	3,090,739	1,419,564	4,187,394	9,355,086
June	650,594	3,588,851	1,037,221	3,770,794	9,047,460
July	530,418	4,175,153	811,353	3,233,236	8,750,160
August	556,107	4,052,448	920,898	2,945,378	8,474,831
September	579,463	3,842,208	843,605	3,496,422	8,761,698
October	593,220	3,650,646	1,168,359	3,987,258	9,399,483
November	646,137	3,403,004	1,137,578	3,611,131	8,797,850
December	524,561	2,794,323	1,003,300	4,705,325	9,027,509
	7,281,979	39,911,048	13,600,931	46,277,757	107,071,715

Month.	Runs from wells.		Field fuel and rail shipments not included in pipe-line runs.	Total.
	Cosden, Gulf, Magnolia, Prairie, and Texas companies' trunk lines.	Private and other lines supplying refineries in Oklahoma and Kansas.		
1915.				
January	4,426,365	1,308,304	622,141	6,356,810
February	4,683,842	1,257,482	612,379	6,553,703
March	5,121,895	1,533,020	774,020	7,428,935
April	8,899,018	1,590,068	761,737	11,250,823
May	5,686,161	1,733,559	343,243	7,762,963
June	5,365,229	2,674,542	323,371	8,363,142
July	6,168,506	2,649,890	295,064	9,113,460
August	5,158,800	2,610,571	197,389	7,966,760
September	5,205,399	2,488,868	179,882	7,874,149
October	5,191,122	2,500,628	151,708	7,843,458
November	5,447,166	2,277,918	198,782	7,923,866
December	6,891,208	2,403,258	182,708	9,477,174
	68,244,711	25,028,108	4,642,424	97,915,243
1916.				
January	5,808,612	2,455,743	176,874	8,441,229
February	5,882,197	2,676,716	204,325	8,763,238
March	6,386,278	3,034,344	211,116	9,631,738
April	5,641,952	2,743,312	236,169	8,621,433
May	6,023,875	3,035,803	295,408	9,355,086
June	5,754,993	3,006,389	286,078	9,047,460
July	5,314,322	3,143,437	292,401	8,750,160
August	5,159,011	3,060,475	255,345	8,474,831
September	5,150,206	3,372,274	239,218	8,761,698
October	5,286,663	3,875,565	237,255	9,399,483
November	4,786,612	3,819,674	191,564	8,797,850
December	5,525,370	3,336,636	165,503	9,027,509
	66,720,091	37,560,368	2,791,256	107,071,715

[a] Includes Wheeler.

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GLENN POOL.

Petroleum marketed from Glenn pool, 1912–1916, in barrels.

Month.	1912	1913	1914	1915	1916
January	882,385	792,336	839,483	464,627	528,265
February	867,566	718,580	769,809	421,922	614,390
March	924,144	807,022	871,334	459,546	838,580
April	898,527	823,645	849,316	455,184	562,855
May	927,182	850,607	897,397	508,786	657,389
June	816,028	816,789	852,901	462,224	650,594
July	880,906	787,274	828,350	551,222	530,418
August	927,675	734,476	535,027	555,514	556,107
September	794,958	773,847	431,051	518,546	579,463
October	921,736	817,628	584,178	534,608	593,220
November	768,254	753,115	604,397	520,012	646,137
December	886,157	794,551	614,346	541,437	524,561
	10,495,518	9,469,870	8,677,589	5,993,628	7,281,979

OSAGE COUNTY.

Petroleum marketed in Osage County from Jan. 1, 1903, to Dec. 31, 1916, in barrels.

1903	56,905	1908	4,961,147	1913	9,009,996
1904	652,479	1909	4,516,524	1914	9,935,692
1905	3,421,478	1910	5,892,970	1915	8,604,389
1906	5,219,106	1911	11,707,676	1916	8,852,843
1907	5,143,971	1912	8,169,158		

Amount received by Osage Nation for royalty oil and gas from wells in Osage County 1911–1916.

Year.	Oil.	Gas.	Total.	Year.	Oil.	Gas.	Total.
1911	$691,399	$3,489	$694,888	1914	$993,770	$10,252	$1,004,022
1912	677,739	3,895	681 634	1915	629,539	13,689	632,228
1913	1,033,530	5,943	1,039,473	1916	1,730,674	497,522	2,228,196

The table following shows the number of wells owned in Osage County by the Indian Territory Illuminating Oil Co. and its sublessees:

Oil and gas wells in Osage County, 1903–1916.

Date.	Completed.	Productive.	Gas.	Dry.a	Date.	Completed.	Productive.	Gas.	Dry.a
Jan. 1, 1903	30	17	2	11	Dec. 31, 1908	1,422	936	78	408
Dec. 31, 1904	361	243	21	97	Dec. 31, 1909	1,574	1,027	81	466
June 10, 1905	544	355	34	155	Dec. 31, 1910	1,735	1,175	82	478
Dec. 31, 1905	704	462	45	197	Dec. 31, 1911	2,233	1,562	90	581
June 10, 1906	862	569	55	238	Dec. 31, 1912	2,682	1,887	112	683
Dec. 31, 1906	1,080	716	66	298	Dec. 31, 1913	3,307	2,323	145	839
June 30, 1907	1,155	779	67	309	Dec. 31, 1914	3,785	2,654	172	959
Dec. 31, 1907	1,277	837	71	369	June 30, 1916	4,211	2,838	227	1,146
					Dec. 31, 1916	4,430	2,968	274	1,188

a Wells that have been exhausted and abandoned in addition to wells that were dry when drilled in.

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SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade journal sources and differ somewhat from those on page 708, obtained from reports received directly from the oil producers:

Well record in Oklahoma in 1915 and 1916.

District and pool.	1915					1916				
	Wells completed.			Initial daily production (barrels).		Wells completed.			Initial daily production (barrels).	
	Oil.	Dry.	Total.[a]	Total.	Average per well.	Oil.	Dry.	Total.[a]	Total.	Average per well.
Cherokee, deep sand: Bartlesville, Hogshooter.. Copan, Ramsey, Wann... Dewey	183	33	242	2,223	12.1	601	65	700	10,391	17.3
Bird Creek, Owasso, Collinsville, Vera	141	45	229	5,703	40.4	486	88	594	8,403	17.3
	324	78	471	7,926	24.5	1,087	153	1,294	18,794	17.3
Cherokee, shallow sand: Delaware, Alluwe, Chelsea	519	54	600	10,595	20.4	1,105	95	1,219	15,972	14.5
Pawnee: Cleveland	47	26	76	1,328	28.3	140	46	197	6,058	43.3
Creek:										
Bald Hill	197	70	275	11,110	56.4	413	96	522	13,655	33.1
Cushing	967	66	1,056	834,980	863.5	785	62	904	230,634	293.8
Glenn, Taneha, Sapulpa, Tulsa, Inola, Wicey, Kelleyville	413	108	575	20,934	50.7	781	140	988	49,268	63.1
Morris, Okmulgee	75	32	113	3,575	47.7	139	60	211	9,470	68.1
Muskogee, Wagoner, Broken Arrow	317	233	617	39,057	123.2	583	268	911	56,581	97.1
Shulter, McIntosh, Okfuskee, Depew	42	41	98	2,365	56.3	53	89	161	2,185	41.2
Mounds, Hamilton Switch	33	11	44	1,300	39.4	40	12	55	1,985	49.6
Miscellaneous		4	6							
	2,014	565	2,784	913,321	446.8	2,794	727	3,752	363,778	130.2
Healdton[b]	289	22	318	85,320	295.2	663	17	685	83,940	126.6
Osage	139	31	190	15,830	113.9	227	28	281	24,580	10.8
Comanche County	5	8	18	35	7.0	28	3	31	338	12.1
Garfield County		1	1			1	1	2	50	50.0
Hughes County	1	5	6	40	40.0		4	4		
Jefferson County		13	13			2	6	8	85	42.5
Kay County	16	10	32	1,630	101.9	30	9	52	8,060	268.7
Marshall County	2	24	37	10	5.0		5	6		
Pittsburg County		3	6			1	1	6	10	10.0
Pontotoc County	1	10	23	5	5.0	6	5	18	120	20.0
Stephens County	10	6	18	130	13.0	2	5	7	110	55.0
Miscellaneous		29	31				15	21		
	3,397	885	4,624	1,036,170	305.0	6,086	1,120	7,583	521,895	85.8

[a] Including gas wells.

[b] Including other tests in Carter County.

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Wells completed in Oklahoma, 1912–1916.

District.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Cherokee, deep	2,444	2,724	1,331	324	1,087	256	299	236	78	153	2,906	3,249	1,789	471	1,294
Cherokee, shallow	761	1,071	1,472	519	1,105	87	139	77	54	95	881	1,231	1,558	600	1,219
Cleveland	196	187	77	47	140	46	68	27	26	46	253	262	111	76	197
Creek	852	2,404	2,651	2,044	2,794	344	654	719	565	727	1,346	3,313	3,573	2,784	3,752
Healdton[b]	.....	15	340	289	663	.....	5	43	22	17	.....	23	392	318	685
Osage	417	506	423	139	227	54	69	99	31	28	489	620	572	190	281
Comanche County	.....	.....	5	5	28	.....	.....	2	8	3	.....	.....	14	18	31
Garfield County	.....	.....	.....	.....	1	.....	.....	.....	1	1	.....	.....	.....	1	2
Hughes County	.....	.....	.....	1	.....	.....	.....	4	5	4	.....	.....	4	6	4
Jefferson County	.....	.....	2	.....	2	.....	.....	13	13	6	.....	.....	15	13	8
Kay County	31	29	58	16	30	20	23	49	10	9	58	55	113	32	52
Kiowa County	.....	.....	33	.....	.....	.....	.....	1	.....	.....	.....	.....	36	.....	.....
Marshall County	.....	.....	3	2	.....	.....	.....	2	24	5	.....	.....	9	37	6
Pittsburg County	.....	.....	.....	.....	1	.....	.....	2	3	1	.....	.....	4	6	6
Pontotoc County	.....	.....	10	1	6	.....	.....	10	10	5	.....	.....	26	23	18
Stephens County	.....	.....	.....	10	2	.....	.....	3	6	5	.....	.....	7	18	7
Miscellaneous	11	29	5	.....	.....	36	51	56	29	15	60	98	69	31	21
	4,712	6,965	6,410	3,397	6,086	843	1,308	1,343	885	1,120	5,993	8,851	8,292	4,624	7,583

[a] Including gas wells. [b] Including other tests in Carter County.

Oil wells and dry holes drilled in Oklahoma in 1916.

District.	January.		February.		March.		April.		May.		June.		July.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Cherokee, deep	68	10	66	15	110	20	170	32	190	23	148	12	113	5
Cherokee, shallow	158	5	108	7	83	18	116	9	140	22	140	.....	156	10
Cleveland	2	3	3	4	18	3	20	6	23	4	21	7	13	2
Creek	196	58	197	66	235	88	216	90	281	63	283	77	270	57
Healdton	64	3	64	3	92	2	74	1	85	2	65	4	95	2
Osage	18	.....	18	6	20	.....	23	1	17	4	10	3	14	1
Comanche County	.....	.....	.....	.....	.....	.....	2	.....	10	.....	9	1	.....	.....
Garfield County	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....
Hughes County	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	.....	.....	.....	.....
Jefferson County	.....	1	1	.....	1	.....	.....	.....	.....	3	.....	.....	.....	.....
Kay County	5	.....	1	.....	6	2	5	1	4	.....	2	.....	1	1
Marshall County	.....	1	.....	.....	.....	.....	.....	.....	.....	4	.....	.....	.....	.....
Pittsburg County	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pontotoc County	1	1	.....	1	1	.....	1	.....	.....	2	1	.....	1	.....
Stephens County	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....
Miscellaneous	.....	1	.....	.....	.....	2	.....	5	.....	2	.....	.....	.....	.....
	512	84	458	102	566	136	627	145	750	133	679	106	663	78

District.	August.		September.		October.		November.		December.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Cherokee, deep	95	15	45	8	15	8	37	3	30	2	1,067	153
Cherokee, shallow	85	6	50	3	12	8	33	4	24	3	1,105	95
Cleveland	10	3	10	3	13	8	4	3	3	.....	140	46
Creek	282	58	206	53	256	43	180	26	192	43	2,794	727
Healdton	34	.....	23	.....	30	.....	19	.....	18	.....	663	17
Osage	19	6	25	1	16	2	12	3	35	1	227	23
Comanche County	.....	.....	.....	.....	.....	.....	.....	1	7	1	28	3
Garfield County	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1	1
Hughes County	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
Jefferson County	.....	1	.....	1	.....	.....	.....	.....	.....	.....	2	6
Kay County	2	2	1	1	1	.....	1	.....	1	2	30	9
Marshall County	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5
Pittsburg County	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1	1
Pontotoc County	.....	.....	1	.....	.....	.....	.....	.....	.....	1	6	5
Stephens County	.....	.....	1	1	1	2	.....	.....	.....	.....	2	5
Miscellaneous	.....	1	.....	3	.....	.....	.....	1	.....	.....	.....	15
	527	92	362	74	345	71	286	41	311	58	6,086	1,120

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Wells completed in Oklahoma, 1912–1916.

Month.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
January	135	375	684	213	512	28	69	153	56	84	180	483	876	292	626
February	269	433	653	225	458	61	61	138	52	102	366	530	849	297	592
March	288	401	733	196	566	46	67	149	63	136	361	492	929	285	738
April	388	470	725	236	627	77	46	190	56	145	508	548	974	324	805
May	386	624	796	214	750	77	111	178	30	133	501	793	1,044	275	945
June	495	664	660	219	679	96	135	116	51	106	636	885	829	285	902
July	458	647	531	205	663	70	180	101	45	78	566	884	668	263	757
August	430	691	469	216	527	62	130	81	58	92	526	864	588	287	649
September	427	626	438	178	362	70	97	72	82	74	527	775	527	292	467
October	456	656	282	364	345	97	125	44	81	71	592	830	372	485	454
November	506	669	186	497	286	100	122	52	164	41	654	846	278	711	349
December	474	709	253	635	311	69	165	69	138	58	576	931	358	828	398
	4,712	6,965	6,410	3,397	6,086	843	1,306	1,343	885	1,120	5,993	8,851	8,292	4,624	7,583

[a] Including gas wells.

Initial daily production of new wells completed in Oklahoma in 1916, in barrels.

District.	January.	February.	March.	April.	May.	June.	July.
Cherokee, deep	1,605	1,746	840	2,654	2,781	3,173	2,015
Cherokee, shallow	1,987	1,303	999	1,631	2,570	1,573	2,579
Cleveland	30	303	685	500	730	1,005	560
Creek	17,430	42,464	25,728	25,766	42,061	68,235	38,595
Healdton	10,010	8,410	13,330	9,220	11,345	11,505	8,645
Osage	1,420	1,335	1,055	550	2,945	475	5,700
Comanche County				25	103	125	
Garfield County							
Jefferson County		75	10				
Kay County	375	750	690	615	645	50	1,000
Pittsburg County							
Pontotoc County	10		10	10		40	20
Stephens County							
	32,867	56,386	43,347	40,971	63,180	86,181	59,114

District.	August.	September.	October.	November.	December.	Total.
Cherokee, deep	1,655	655	515	600	555	18,794
Cherokee, shallow	1,241	869	280	580	360	15,972
Cleveland	310	1,275	335	130	195	6,058
Creek	26,628	16,289	24,050	16,825	19,707	363,778
Healdton	2,905	2,475	1,870	2,125	2,100	83,940
Osage	2,935	2,150	2,510	955	2,550	24,580
Comanche County					85	338
Garfield County			50			50
Jefferson County						85
Kay County	85	1,000	1,200	150	1,500	8,060
Pittsburg County					10	10
Pontotoc County		30				120
Stephens County		10	100			110
	35,759	24,753	30,910	21,365	27,062	521,895

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Total and average initial daily production of new wells in Oklahoma, 1912–1916, by districts, in barrels.

District.	Total initial production.					Average per well.				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Cherokee, deep	76,025	67,505	19,986	7,926	18,794	31.1	24.8	15.0	24.5	17.3
Cherokee, shallow	10,930	17,672	16,172	10,595	15,972	14.3	16.5	11.0	20.4	14.5
Cleveland	33,903	15,787	3,905	1,328	6,058	173.0	84.4	50.7	28.3	43.3
Creek	77,588	193,796	797,060	913,321	363,778	91.1	80.6	300.7	446.8	130.2
Healdton		844	106,171	85,320	83,940		56.3	312.3	295.2	126.6
Osage	25,400	34,856	26,787	15,830	24,580	60.9	68.9	63.3	113.9	108.3
Comanche County			59	35	338			11.8	7.0	12.1
Garfield County					50					50.0
Hughes County				40					40.0	
Jefferson County			215		85			107.5		42.5
Kay County	4,790	2,964	5,417	1,630	8,060	154.5	102.2	93.4	101.9	268.7
Kiowa County			185					5.6		
Marshall County			15	10				5.0	5.0	
Pittsburg County					10					10.0
Pontotoc County			172	5	120			17.2	5.0	20.0
Stephens County				130	110				13.0	55.0
Miscellaneous	250	626	100			22.7	21.6	20.0		
	228,886	334,050	976,244	1,036,170	521,895	48.6	48.0	152.3	305.0	85.8

Total initial daily production of new wells in Oklahoma, 1912–1916, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1912	9,448	13,807	12,281	17,329	10,993	17,617	18,507	24,635	22,096	27,519	27,599	27,055	228,886	19,074
1913	19,220	19,505	21,615	29,847	27,139	32,192	26,071	27,897	27,267	30,953	29,211	43,133	334,050	27,838
1914	27,785	40,344	60,201	61,233	102,674	128,886	84,652	91,886	92,453	81,357	71,488	133,285	976,244	81,354
1915	128,484	117,313	85,070	149,406	124,455	113,210	76,440	48,698	24,730	61,242	64,248	47,874	1,036,170	86,348
1916	32,867	56,386	43,347	40,971	63,180	86,181	59,114	35,759	24,753	30,910	21,365	27,062	521,895	43,491

GULF OIL FIELD.

GENERAL STATEMENT.

The term Gulf field as used in this report includes that portion of the Gulf Coastal Plain of Texas and Louisiana in which petroleum is found in domes, associated with rock salt and gypsum. In this area the age of the oil-bearing strata ranges from Cretaceous to Quaternary and the reservoir rock is generally either porous dolomitic limestone or sandstone.

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MARKETED PRODUCTION.

Petroleum marketed in the Gulf field in 1915 and 1916, in barrels.

Month.	1915			1916		
	Coastal Texas.	Coastal Louisiana.	Total.	Coastal Texas.	Coastal Louisiana.	Total.
January	953,055	237,295	1,190,350	1,923,102	217,686	2,140,788
February	1,152,751	270,505	1,423,256	1,684,089	305,984	1,990,073
March	1,195,038	273,751	1,468,789	1,634,699	347,022	1,981,721
April	1,143,093	288,017	1,431,110	1,482,871	328,885	1,811,756
May	1,024,212	223,516	1,247,728	1,669,835	314,046	1,983,881
June	1,099,526	230,525	1,330,051	1,492,890	305,757	1,798,647
July	1,314,341	244,508	1,558,849	1,420,359	304,154	1,724,513
August	1,212,867	273,428	1,486,295	1,408,895	280,832	1,689,727
September	1,631,486	246,323	1,877,809	1,354,651	227,633	1,582,284
October	2,146,349	290,972	2,437,321	1,408,370	258,963	1,667,333
November	2,575,022	248,679	2,823,701	1,268,182	270,090	1,538,272
December	2,021,406	281,986	2,303,394	1,593,657	265,444	1,859,101
	17,469,148	3,109,505	20,578,653	18,341,600	3,426,496	21,768,096
Increase, 1916:						
Barrels				872,452	316,991	1,189,443
Per cent				4.99	10.19	5.78

Petroleum marketed in the Gulf field, 1889–1916.

Year.	Production (barrels).	Percentage of total production.	Increase or decrease.		Value.	Yearly average price per barrel.
			Barrels.	Per cent.		
1889	48				$340	$7.084
1890	54		+ 6	+ 12.50	227	4.204
1891	54				227	4.204
1892	45		− 9	− 16.67	225	5.000
1893	50		+ 5	+ 11.11	210	4.200
1894	60		+ 10	+ 20.00	300	5.000
1895	50		− 10	− 16.67	250	5.000
1896	50				250	5.000
1897	50				250	5.000
1898	1,450		+ 1,400	+2,800.00	7,250	5.000
1899	530		− 920	− 63.45	2,650	5.000
1900	0		− 530	− 100.00		
1901	3,593,113	5.18	+ 3,593,113		630,752	.175
1902	18,014,404	20.29	+14,421,291	+ 401.36	3,766,683	.209
1903	18,371,383	18.29	+ 356,979	+ 1.98	7,418,393	.411
1904	24,631,269	21.03	+ 6,259,886	+ 34.07	8,817,454	.357
1905	36,526,323	27.11	+11,895,054	+ 48.29	8,791,983	.240
1906	20,524,162	16.23	−16,002,161	− 43.81	9,380,691	.457
1907	16,360,299	9.85	− 4,163,863	− 20.29	13,704,469	.837
1908	15,772,137	8.83	− 588,162	− 3.60	9,511,907	.603
1909	10,883,240	5.94	− 4,888,897	− 30.00	7,872,086	.723
1910	9,680,465	4.62	− 1,202,775	− 11.05	7,383,571	.763
1911	10,999,873	4.99	+ 1,319,408	+ 13.63	7,355,681	.669
1912	8,545,040	3.83	− 2,454,833	− 22.32	6,344,184	.742
1913	8,542,494	3.44	− 2,546	− .03	7,993,997	.936
1914	13,118,028	4.94	+ 4,575,534	+ 53.56	8,844,604	.674
1915	20,578,653	7.32	+ 7,460,625	+ 56.87	9,809,301	.477
1916	21,768,096	7.24	+ 1,189,443	+ 5.78	16,416,374	.754
	257,911,420	6.584			134,054,509	.520

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Petroleum marketed, value, and average price per barrel in the Gulf field, 1907–1916.

Year.	Coastal Texas.			Coastal Louisiana.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1907	11,410,078	$9,680,286	$0.848	4,950,221	$4,024,183	$0.813	16,360,299	$13,704,469	$0.837
1908	10,483,200	6,221,636	.593	5,288,937	3,289,371	.622	15,772,137	9,511,007	.603
1909	8,852,527	6,399,318	.723	2,030,713	1,473,368	.725	10,883,240	7,872,686	.723
1910	7,929,863	6,100,359	.769	1,750,602	1,283,212	.733	9,680,465	7,383,571	.763
1911	7,275,281	5,340,592	.734	3,724,592	2,015,089	.541	10,999,873	7,355,681	.669
1912	6,459,550	4,739,898	.734	2,085,490	1,604,286	.769	8,545,040	6,344,184	.742
1913	5,825,226	5,550,408	.953	2,717,268	2,443,589	.899	8,542,494	7,993,997	.936
1914	10,617,062	7,164,393	.675	2,500,966	1,680,211	.672	13,118,028	8,844,604	.674
1915	17,469,148	8,399,991	.479	3,109,505	1,439,310	.463	20,578,653	9,809,301	.477
1916	18,341,600	13,925,362	.759	3,426,496	2,491,512	.727	21,768,096	16,416,874	.754

Petroleum marketed in the Gulf field, 1912–1916, in barrels.

Month.	1912	1913	1914	1915	1916
January	717,941	704,900	802,249	1,190,350	2,140,788
February	741,842	610,703	748,403	1,423,256	1,990,073
March	784,730	876,333	1,068,009	1,468,789	1,981,721
April	752,587	756,342	1,227,381	1,431,110	1,811,756
May	707,766	757,767	1,256,802	1,247,728	1,983,881
June	684,210	696,534	1,259,829	1,330,051	1,798,647
July	713,914	676,240	1,125,064	1,558,849	1,724,513
August	700,647	687,520	1,139,398	1,486,295	1,689,727
September	675,053	683,938	1,101,244	1,877,809	1,582,284
October	670,535	678,060	1,222,204	2,437,321	1,667,333
November	684,345	671,789	1,104,531	2,823,701	1,538,272
December	711,470	742,368	1,062,914	2,303,394	1,859,101
	8,545,040	8,542,494	13,118,028	20,578,653	21,768,096

Average daily production of petroleum in the Gulf field, 1912–1916, in barrels.

Month.	1912	1913	1914	1915	1916
January	23,159	22,739	25,879	38,398	69,058
February	25,581	21,811	26,728	50,831	68,623
March	25,314	28,269	34,452	47,380	63,926
April	25,086	25,211	40,913	47,704	60,392
May	22,831	24,445	40,542	40,249	63,996
June	22,807	23,218	41,994	44,335	59,955
July	23,029	21,814	36,292	50,285	55,629
August	22,601	22,178	36,755	47,945	54,507
September	22,502	22,798	36,708	62,594	52,743
October	21,630	21,873	39,426	78,623	53,783
November	22,811	22,393	36,818	94,123	51,276
December	22,951	23,947	34,288	74,303	59,971
Average	23,347	23,404	35,940	56,380	59,476

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PIPE-LINE RUNS, DELIVERIES, AND STOCKS.

Pipe-line runs and deliveries to trade of petroleum from the Gulf field and stocks at end of each month in 1915 and 1916, in barrels.

Month.	1915			1916		
	Runs.	Deliveries.	Stocks.	Runs.	Deliveries.	Stocks.
Dec. 31, 1914			3,963,744			
January	1,190,350	887,698	4,266,396	2,140,788	731,574	8,431,619
February	1,423,256	1,145,822	4,544,130	1,990,073	1,510,162	8,911,530
March	1,468,789	1,207,019	4,805,900	1,981,721	1,348,747	9,544,504
April	1,431,110	1,211,206	5,025,804	1,811,756	1,313,844	10,042,416
May	1,247,728	1,232,815	5,040,717	1,963,881	896,528	11,129,769
June	1,330,051	1,709,461	4,661,307	1,798,647	2,485,943	10,442,473
July	1,558,849	1,295,490	4,924,666	1,724,513	1,926,414	10,240,572
August	1,486,295	1,208,006	5,202,955	1,689,727	1,876,461	10,053,838
September	1,877,809	1,653,267	5,427,497	1,582,284	1,945,330	9,690,792
October	2,437,321	1,764,829	6,099,989	1,667,333	1,652,445	9,705,680
November	2,828,701	2,137,501	6,786,189	1,538,272	1,989,313	9,254,639
December	2,303,394	2,067,178	7,022,405	1,859,101	1,799,339	9,314,401
	20,578,653	17,519,992		21,768,096	19,476,100	

PRICES.

Average monthly prices per barrel of petroleum in the Gulf field, 1915 and 1916.

1915.

Month.	Coastal Texas.					
	Batson.	Dayton.	Goose Creek.	Humble.	Markham.	Orange County.
January	$0.40–$0.43	$0.40	$0.50	$0.40–$0.43	$0.45	$0.65
February	.40– .45	.45	.50	.40– .45	.46	.65
March	.40– .45	.45	.50	.40– .45	.50	.65
April	.40– .45	.45	.50	.40– .45	.50	.60
May	.40– .45	.45	.40	.40– .45	.50	.60
June	.40– .45	.45	.50	.40– .45	.50	.60
July	.42– .46	.46	.50	.41– .46	.50	.60
August	.50	.50	.50	.50	.50	.60
September	.50	.50	.50	.50	.50	.60
October	.50	.50	.50	.50	.50	.60
November	.50	.50	.50	.50	.50	.60
December	.53	.53	.50	.53– .54	.54	.60
Average	.403	.466	.515	.482	.510	.615

Month.	Coastal Texas—Continued.			Coastal Louisiana.		
	Saratoga.	Sourlake.	Spindletop.	Edgerly.	Jennings.	Vinton.
January	$0.40–$0.43	$0.40–$0.43	$0.43–$0.45	$0.40	$0.40–$0.45	$0.40–$0.45
February	.40– .45	.40– .45	.45	.40	.40– .45	.40– .45
March	.40– .45	.40– .45	.45	.40	.40– .45	.40– .45
April	.40– .45	.40– .45	.45	.40	.40– .45	.40– .45
May	.40– .45	.40– .45	.45	.40	.40– .45	.40– .45
June	.40– .45	.40– .45	.45	.40	.40– .45	.40 .45
July	.42– .46	.41– .46	.46– .47	.42	.42– .45	.42– .45
August	.50	.50	.50– .55	.50	.45– .50	.50– .59
September	.50	.50	.50– .55	.50	.45– .50	.50– .60
October	.50	.50	.50– .55	.50	.45– .50	.50– .60
November	.50	.50	.50– .55	.50	.45– .50	.50– .60
December	.53	.53– .54	.50– .58	.50	.50– .53	.53– .64
Average	.510	.460	.492	.452	.486	.457

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Average monthly prices per barrel of petroleum in the Gulf field, 1915 and 1916—Con.

1916.

Month.	Coastal Texas.					
	Batson, Saratoga, Spindletop.	Dayton.	Goose Creek.	Humble.	Sourlake.	Markham.
January	$0.76–$0.82	$0.76	$0.65	$0.76–$0.77	$0.76–$0.82	$0.69
February	.80– .85	.80	.65	.80	.80– .85	.70
March	.80– .85	.80	.65	.80	.80– .85	.70
April	.80– .85	.80	.65	.80	.80– .85	.70
May	.80– .85	.80	.65	.80	.80– .85	.70
June	.80– .85	.80	.65	.80	.80– .85	.70
July	.73– .75	.75	.65	.68– .75	.73– .75	.69
August	.65– .70	.65	.65	.65	.65– .70	.65
September	.65– .70	.65	.65	.65	.65– .70	.65
October	.65– .70	.65	.65	.65	.65– .70	.65
November	.65– .70	.65	.65	.65	.65– .70	.65
December	.77– .81	.77	.79	.76– .78	.77– .80	.69
Average	.741	.749	.736	.766	.726	.695

Month.	Coastal Louisiana.		
	Edgerly.	Jennings.	Vinton.
January	$0.67	$0.64–$0.77	$0.76–$0.79
February	.70	.65– .80	.80
March	.70	.65– .80	.80
April	.70	.65– .80	.80
May	.75	.65– .90	.80– .90
June	.75	.65– .90	.80– .90
July	.64	.65– .79	.74– .79
August	.60	.65	.65
September	.60	.65	.65
October	.60	.65	.65
November	.60	.65	.65
December	.73	.77– .78	.77– .78
Average	.699	.754	.787

Prices paid for Gulf oil per barrel in 1915 and 1916 by the principal pipe-line companies, and dates on which the changes were made.

1915.

Date.	Coastal Texas.									
	Batson.		Dayton.	Goose Creek.	Humble.			Markham.	Saratoga.	
	Gulf.	Sun.	Sun.	Gulf.	Gulf.	Sun.	Texas.	Texas.	Gulf.	Sun.
Jan. 1	$0.40	$0.40	$0.30	$0.50	$0.40	$0.40	$0.40	$0.45	$0.40	$0.40
Jan. 11	.....	.45	.45	.....	.....	.45	.....	.....	.....	.45
Feb. 19	.....	.....	.....	.....	.....	.....	.....	.50	.....	.....
May	.....	.....	.....	.40	.....	.....	.....	.....	.....	.....
July	.....	.....	.....	.50	.....	.....	.....	.....	.....	.....
July 23	.....	.50	.50	.....	.....	.50	.....	.....	.....	.50
July 26	.50	.....	.....	.....	.50	.....	.....	.....	.50	.....
July 28	.....	.....	.....	.....	.....	.....	.50	.....	.....	.....
Aug. 3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Dec. 20	.....	.....	.....	.....	.....	.....	.60	.60	.....	.....
Dec. 22	.....	.60	.60	.....	.....	.60	.....	.....	.....	.60
Dec. 23	.60	.....	.....	.....	.60	.....	.....	.....	.60	.....

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Prices paid for Gulf oil per barrel in 1915 and 1916 by the principal pipe-line companies, and dates on which the changes were made—Continued.

1915—Continued.

Date.	Coastal Texas—Continued.					Coastal Louisiana.					
	Sour Lake.			Spindletop.		Edgerly.	Jennings.		Vinton.		
	Gulf.	Sun.	Texas.	Gulf.	Sun.	Gulf.	Gulf.	Texas.	Gulf.	Sun.	Texas.
Jan. 1	$0.40	$0.40	$0.40	$0.45	$0.40	$0.40	$0.40	$0.45	$0.40	$0.40	$0.45
Jan. 11	.....	.45	.....	.....	.45	.....	.....	.....	.....	.....	.....
Feb. 19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
May	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
July	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
July 23	.....	.50	.....	.....	.50	.....	.....	.....	.....	.....	.....
July 26	.50	.....	.....	.55	.....	.50	.50	.....	.50	.50	.....
July 28	.....	.....	.50	.....	.....	.....	.....	.....	.....	.....	.....
Aug. 8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.60
Dec. 20	.....	.....	.60	.....	.....	.....	.....	.55	.....	.....	.70
Dec. 22	.....	.60	.....	.....	.60	.....	.....	.....	.....	.....	.....
Dec. 23	.60	.....	.....	.65	.....	.....	.60	.....	.60	.60	.....

1916.

Date.	Coastal Texas.						
	Batson, Saratoga, Spindletop.	Dayton.	Goose Creek.	Humble.		
	Gulf.	Sun.	Sun.	Gulf.	Gulf.	Sun.	Texas.
Jan. 1	$0.65	$0.60	$0.60	$0.65	$0.60	$0.60	$0.60
Jan. 4	.75	.....	.....	.....	.70	.....	.70
Jan. 5	.....	.70	.70	.....	.....	.70	.....
Jan. 8	.85	.....	.....	.....	.80	.....	.....
Jan. 10	.....	.80	.80	.....	.....	.80	.80
Jan. 11	.....	.....	.....	.....	.....	.....	.....
May 1	.....	.....	.....	.....	.....	.....	.....
July 1	.75	.....	.....	.....	.70	.....	.....
July 14	.....	.....	.....	.....	.....	.....	.70
July 17	.70	.....	.....	.....	.65	.....	.....
July 18	.....	.70	.70	.....	.....	.70	.....
July 26	.....	.....	.....	.....	.....	.....	.....
July 27	.....	.65	.65	.....	.....	.65	.....
July 28	.....	.....	.....	.....	.....	.....	.65
Dec. 6	.80	.....	.75	.75	.....	.....	.....
Dec. 8	.....	.75	.75	.....	.....	.75	.80
Dec. 11	.....	.....	.....	.....	.....	.....	.....
Dec. 12	.....	.....	.....	.....	.....	.....	.....
Dec. 13	.....	.....	.80	.....	.....	.....	.....
Dec. 14	.....	.80	.80	.....	.....	.80	.....
Dec. 20	.....	.....	.....	.....	.....	.....	.....
Dec. 26	.....	.....	.....	.....	.....	.....	.....
Dec. 28	.95	.....	.90	.90	.....	.....	.....
Dec. 29	1.05	.....	1.00	1.00	.....	.....	.....
Dec. 30	.....	1.00	1.00	.....	.....	1.00	1.00

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Prices paid for Gulf oil per barrel in 1915 and 1916 by the principal pipe-line companies, and duties on which the changes were made—Continued.

1916—Continued.

Date.	Coastal Texas.—Continued.				Coastal Louisiana.					
	Sourlake.			Markham.	Edgerly.	Jennings.		Vinton.		
	Gulf.	Sun.	Texas.	Texas.	Gulf.	Gulf.	Texas.	Gulf.	Sun.	Texas.
Jan. 1	$0.65	$0.60	$0.60	$0.60	$0.50	$0.60	$0.55	$0.60	$0.60	$0.70
Jan. 4	.75	.....	.70	.70	.60	.70	.65	.70	.....	.80
Jan. 5	.....	.70	.....	.....	.....	.....	.....	.....	.70	.....
Jan. 8	.85	.....	.....	.....	.70	.80	.....	.80	.....	.....
Jan. 10	.....	.80	.....	.....	.....	.....	.....	.....	.80	.....
Jan. 11	.....	.....	.80	.....	.....	.....	.....	.....	.....	.....
May 1	.....	.....	.....	.....	.75	.90	.....	.90	.....	.....
July 1	.75	.....	.....	.....	.65	.....	.....	.....	.....	.....
July 14	.....	.....	.70	.....	.....	.....	.....	.....	.....	.70
July 17	.70	.....	.....	.....	.....	.70	.....	.70	.....	.....
July 18	.....	.70	.....	.....	.....	.....	.....	.....	.70	.....
July 26	.....	.....	.....	.....	.60	.65	.....	.65	.....	.....
July 27	.....	.65	.....	.....	.....	.....	.....	.....	.65	.....
July 28	.....	.....	.65	.65	.....	.....	.....	.....	.....	.65
Dec. 6	.80	.....	.....	.....	.....	.....	.....	.....	.....	.....
Dec. 8	.....	.75	.80	.....	.....	.....	.80	.....	.75	.80
Dec. 11	.....	.....	.....	.....	.70	.75	.....	.75	.....	.....
Dec. 12	.....	.....	.....	.....	.75	.80	.....	.80	.....	.....
Dec. 13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Dec. 14	.....	.80	.....	.....	.....	.....	.....	.....	.80	.....
Dec. 20	.....	.....	.....	.75	.....	.....	.....	.....	.....	.....
Dec. 26	.....	.....	.....	.....	.85	.....	.....	.....	.....	.....
Dec. 28	.95	.....	.....	.....	.....	.90	.....	.90	.....	.....
Dec. 29	1.05	.....	.....	.....	.95	1.00	.....	1.00	.....	.....
Dec. 30	.....	1.00	1.00	.....	.....	.....	1.00	.....	1.00	1.00

SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on pages 708–709, obtained from reports received directly from the oil producers:

Wells completed in the Gulf field, 1912–1916.

District.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Coastal and southern Texas	353	325	323	306	647	109	255	130	230	355	462	592	464	541	1,030
Coastal Louisiana	59	81	72	73	104	25	56	45	26	41	84	138	118	101	146
	412	406	395	379	751	134	311	175	256	396	546	730	582	642	1,176

[a] Including gas wells.

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Oil wells and dry holes drilled in the Gulf field in 1916.

District.	January.		February.		March.		April.		May.		June.		July.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Coastal and southern Texas..	41	27	47	32	66	25	74	29	90	48	57	36	56	33
Coastal Louisiana.....	6	5	9	2	8	2	8	2	4	2	10	9	9	4
	47	32	56	34	74	27	82	31	94	50	67	45	65	37

District.	August.		September.		October.		November.		December.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Coastal and southern Texas.	49	29	39	26	37	15	39	26	52	29	647	355
Coastal Louisiana.....	11	5	9	3	8	4	10	.....	12	3	104	41
	60	34	48	29	45	19	49	26	64	32	751	396

Wells completed in the Gulf field, 1912–1915.

Month.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
January.....	16	31	45	24	47	8	9	5	11	32	24	42	51	35	84
February.....	44	30	26	28	56	9	26	8	7	34	53	56	37	35	92
March.....	39	43	26	20	74	8	16	13	16	27	47	60	39	36	101
April.....	47	42	24	22	82	15	45	21	23	31	62	90	46	45	115
May.....	29	26	45	31	94	14	16	14	14	50	43	46	61	45	149
June.....	30	40	35	38	67	14	41	12	35	45	44	84	47	74	115
July.....	28	48	43	38	65	9	33	24	36	37	37	81	68	75	104
August.....	35	43	35	34	60	12	34	26	18	34	47	77	63	53	96
September.....	34	29	28	38	48	14	22	10	27	29	48	51	39	65	79
October.....	40	27	25	26	45	13	22	18	13	19	53	49	43	39	64
November.....	43	21	34	42	49	8	17	18	30	26	51	37	53	73	79
December.....	27	26	29	38	64	10	32	9	26	32	37	58	38	67	98
	412	406	395	379	751	134	311	175	256	396	546	730	582	642	1,176

[a] Including gas wells.

Initial daily production of new wells completed in the Gulf field in 1916, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Coastal and southern Texas.....	49,515	55,732	60,959	24,008	56,020	36,580	14,149	10,834	11,970	23,425	12,580	32,650	388,422
Coastal Louisiana...	27,865	12,150	20,300	6,075	3,260	6,195	4,900	4,850	7,040	2,245	5,300	11,130	111,310
	77,380	67,882	81,259	30,083	59,280	42,775	19,049	15,684	19,010	25,670	17,880	43,780	499,732

Total and average initial daily production of new wells in the Gulf field, 1912–1916, by districts, in barrels.

District.	Total initial production.					Average per well.				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Coastal and southern Texas.....	33,082	38,978	160,695	292,541	388,422	93.7	119.9	497.5	956.0	600.3
Coastal Louisiana.....	25,520	55,740	82,914	45,185	111,310	432.5	688.1	1,151.6	619.0	1,070.3
	58,602	94,718	243,609	337,726	499,732	142.2	233.3	616.7	891.1	665.[illegible]

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Total initial daily production of new wells in the Gulf field, 1912–1916, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1912.....	2,670	5,690	4,679	3,885	2,030	2,575	7,475	3,313	12,045	1,170	7,779	5,291	58,602	4,884
1913.....	15,712	4,447	27,571	10,300	8,335	5,525	4,275	4,584	2,067	3,459	1,066	7,357	94,718	7,893
1914.....	10,551	7,101	31,975	40,624	16,071	23,652	26,085	13,043	28,685	15,520	17,772	12,530	243,609	20,301
1915.....	15,680	15,398	6,485	8,020	13,285	20,265	18,300	16,875	40,053	68,815	89,050	26,500	337,726	28,144
1916.....	77,380	67,882	81,259	30,083	59,280	42,775	19,049	15,684	19,010	25,670	17,880	43,780	499,732	41,644

TEXAS.

GENERAL STATEMENT.

The petroleum output of Texas in 1916, which was 27,644,605 barrels, was greater by 2,701,904 barrels, or 11 per cent, than the output in 1915 and was less by only 491,584 barrels, or 2 per cent, than the record output of 28,136,189 barrels in 1905. Of the output in 1916, the northern or stratum division contributed 34 per cent and the coastal or salt-dome division 66 per cent, as against 30 per cent and 70 per cent, respectively, in 1915. The net gain over 1915 in the northern division was 1,829,452 barrels, or 24 per cent, whereas that in the coastal division was only 872,452 barrels, or 5 per cent. To Wichita County in the stratum division and to the Sourlake pool in the salt-dome division belongs the greater part of the credit for this increase, though other districts assisted in making it possible.

Although Texas was able to retain in 1916 the rank of third among the oil-producing States on the basis of the quantity of oil marketed, it attained only fourth place on the basis of the value of oil marketed. This, however, was an advance of one place over 1915, gained by exchange with West Virginia.

The average price received at the wells for all grades of oil marketed in Texas in 1916 was 93 cents a barrel, and the total market value of the output was $25,760,335, a gain of 41 cents in average unit price and of $12,733,410, or 98 per cent, in total market value, compared with 1915.

Of the total receipts for sales of crude oil in Texas in 1916, $11,834,973, or 46 per cent, was credited to the stratum division and $13,925,362, or 54 per cent, to the salt-dome division, the average price in the former division being $1.27 a barrel, 65 cents higher than in 1915, and in the latter division 76 cents a barrel, 28 cents higher than in 1915.

The increasing demand for crude petroleum, indicated by the substantial gain in the average market price in 1916, resulted in a quest for new sources of production throughout Texas that constituted a feature of the crude-oil industry in the State second in importance only to the increased production from the proved districts and to the increased value of the oil marketed.

DEVELOPMENT.

The report of field activity in Texas in 1916 shows increase for the entire State of 60 per cent over that in 1915, the gain in the stratum division being 29 per cent and in the salt-dome division 90

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per cent. There were 1,713 wells completed in the State in 1916, of which 1,147, or 67 per cent, produced an estimated average of 382 barrels of oil each the first day of productive life, 66 produced gas, and 500, an average of 5 in every 17, were failures.

STRATUM DIVISION.

Northern Texas.

In the stratum division, which includes the areas of oil production in central and northern Texas, the results of drilling in 1916 include 500 new oil wells, 38 gas wells, and 145 dry holes. The average initial output of the new oil wells was 99 barrels each, compared with 171 barrels in 1915.

Wichita County.—The output of petroleum in Wichita County was 34 per cent greater in 1916 than in 1915, as a consequence in part of the greater activity in drilling resulting from the more favorable market for oil at the wells, but chiefly because of the success that attended deeper drilling in the Electra district. In the western portion of this district the deepening of wells that had been producing for months from sands less than 1,200 feet deep to sands found at depths between 1,900 and 2,000 feet below the surface resulted in the completion of many gusher wells, several of which exceeded 1,500 barrels of oil the first 24 hours after completion. Additional wells near No. 1 Piper, of the Corsicana Petroleum Co. (now Magnolia Petroleum Co.), completed in December, 1915, a mile southwest of previous wells, confirmed an important extension of the Electra district in this direction. Less significant northward extensions of the shallow sand territory at the east end of the district were also proved in 1916.

Drilling was especially active in the Burkburnett district, the territory about Clara receiving the most attention. Wells at the north end of this district, but slightly in advance of producing territory, essentially defined the limits of the field in this direction. At the end of 1916 interest was centered in a test being drilled by Jackson, Boyd, and others on the Bashara farm, half a mile south of the nearest producing well, in which 12 feet of tight sand containing considerable oil had been encountered at a depth of about 1,500 feet.

Renewed activity in 1916 in the Iowa Park, Borcheldt, Fowlkes, and Eads districts resulted in the completion of a few new wells unimportant as to capacity or location.

Wilbarger County.—In the vicinity of Vernon, where an oil well was completed in 1915 by the Producers Oil Co., on the Waggoner ranch, two additional tests completed in 1916 were gas wells having initial capacities estimated in excess of 7,000,000 cubic feet a day.

Clay County.—Developments in 1916 in the Petrolia oil and gas district were devoid of especial interest and the output of this pool was 14 per cent less than in 1915.

Shackelford County.—Attempts to add producing territory to that already under development in the Moran pool met with little success in 1916. Production from the main pool amounted to 135,608 barrels and was 24 per cent greater than in 1915.

Throckmorton County.—North of the Moran district a gas well of small capacity was completed in March, on the Mathews ranch in southern Throckmorton County, a short distance from a similar well drilled three years earlier.

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Palo Pinto County.—In the Strawn district and in the territory adjacent to it drilling was especially active in 1916. The producing area of the Strawn field was materially increased as a consequence of drilling north and west of the area proved in 1915. Oil wells of larger average initial yield than those completed in this field in 1915 were finished in 1916 on the Stuart ranch in the northern extension.

Outside the Strawn district, where the productive territory thus far proved is largely controlled by one company, principal interest in Palo Pinto County was centered in wildcat developments south of Mineral Wells in the eastern part of the county. The discovery, late in 1915, of a fair volume of gas at a depth of 720 feet in a well drilled on the Hess ranch, 5 miles south of Mineral Wells, furnished an incentive for additional drilling in this locality that was rewarded by the opening of a promising gas field. Attempts to drill the discovery well deeper in January, 1916, resulted in its loss by flooding.

A second well a few hundred feet to the northeast, completed in February, was credited with an initial capacity of 3,000,000 cubic feet of gas from a sand found at a depth of 1,060 feet. The completion in March, as a gas well of fair capacity, of a test on the Edmonson ranch, 7 miles south of Mineral Wells, confirmed the discovery of an important gas field in this locality. Subsequent drilling proved the productivity of the territory between the Hess and the Edmonson wells and attracted to the district the Doherty interests, which acquired in July a controlling interest in the new field that assures its efficient development.

Parker County.—The success of operations in eastern Palo Pinto County furnished an incentive for active drilling in Parker County to the east, which resulted in June in the completion, at a depth of 2,300 feet of a gas well of fair capacity on the Mortens ranch, near Millsap, but in disappointment elsewhere.

Stephens County.—The area west of the Strawn district in Stephens County shared in the general increase of wildcat operations. Stimulation was provided in May by the discovery of gas in fair volume and of oil in small quantity at a depth of 2,740 feet in a well drilled on the W. L. Carey farm, 1 mile south of the town of Caddo, and in October by the discovery of oil in considerable quantity with more or less gas at a depth of 3,150 feet in a test on the Parks ranch, 7 miles southeast of Breckenridge. One additional oil well, that of the Texas & Pacific Coal Co., on the Wright farm, completed at a depth of 3,120 feet, was brought in during the year near Caddo, but additional tests in the Breckenridge locality remained unfinished at the end of 1916.

Jack County.—In Jack County, which adjoins Palo Pinto on the north, the shallow-sand territory north of Jacksboro received considerable attention, and a few wells of small capacity were completed there. Several deep tests were begun in this locality in the hope of finding higher grade oil in larger quantities at depth. A test on the Montgomery ranch near Vineyard, in the southeastern part of the county, was abandoned as dry in March at a depth of 2,680 feet.

Archer County.—The revival of drilling activity in Archer County in 1916 was rewarded in August by the discovery of oil in commercial quantities at a depth of 1,630 feet in a well drilled for the Panther Oil Co. on the Luke Wilson ranch, 2½ miles south of Holliday. The finding of this oil at depth in an area where small quantities of oil

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had previously been encountered in shallow wells brought about additional drilling and this was further stimulated by the completion in November by the Coline Oil Co. of a 60-barrel oil well at a depth of 1,605 feet on the Knight farm, 3 miles northwest of Holliday and 5 miles from the Panther well. Before the end of 1916 one barren test had been completed on the Owens farm, midway between the two producing wells in this district, and another equally disappointing on the Wilson ranch, a mile southwest of the Panther well.

Jones County.—A barren test drilled by Honey and others on the Hughes ranch, 8 miles northeast of Stamford, Jones County, was abandoned in July at a depth of 1,960 feet.

Callahan County.—Encouraging showings of oil and of gas at various depths were found in a wildcat test drilled by Cosden & Co. near Putnam, in the northern part of Callahan County, about 10 miles south of the Moran district. To the end of 1916 this well had attained a depth of about 3,300 feet.

Taylor County.—A small quantity of oil was found at a reported depth of 1,900 feet in a well drilled for the Hunch Oil Co. on the Boyer ranch, near Abilene, Taylor County.

Coleman County.—Persistent efforts to find an oil field in the vicinity of the Bangs gas field in Coleman County were rewarded in May by the completion of a 20-barrel oil well on the Pope farm, 3 miles southeast of Santa Anna, and by the finding in September of oil in apparently much larger quantities and accompanied by gas in another well 1½ miles farther to the southeast. The capacity of the latter well had not been determined to the end of 1916 because it was unfortunately drilled too deep into a prolific water-sand.

Hood County.—An unsuccessful test drilled by Charles Mitchell and others on the Codgell ranch, near Granbury, Hood County, was abandoned in June at a depth of 2,565 feet.

Cooke County.—Encouraging showings of oil found in November at a depth between 2,600 and 2,700 feet in a well drilled by Tippett & Darnell, near Myra, 10 miles west of Gainesville, resulted in a shot that unfortunately damaged the casing and prevented a determination of the value of the find.

Northeastern Texas.

Developments in 1916 in Marion and Cass counties, across the State boundary from the Caddo district, La., were without notable incident. A number of wells were completed in these counties, but all were in proved territory.

A new district of apparent promise was indicated in Panola County by the completion in July of a successful wildcat test near Bethany. The initial capacity of the well, which was drilled by the Palmetto Oil Co. on the Trosper lease, was 50 barrels and its total depth was 2,434 feet. Other wells were started on adjacent leases before the end of 1916. The prospective pool in this locality is situated about 25 miles north of the Logansport development, in the western part of De Soto Parish, La.

The wildcat test drilled by the Huntington Oil & Gas Co. near Huntington, Angelina County, was abandoned, dry, in June at a reported depth of 1,150 feet.

An encouraging showing of oil at a depth of about 1,700 feet in a wildcat well drilled by the Producers Oil Co. 8 miles northeast of

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Palestine, Anderson County, attracted considerable favorable attention to the locality in February and March, 1916. The failure of this well to become a producer when it was drilled in, and the subsequent failure of another test near by to yield more than slight indications of oil and gas discouraged further ventures.

As a consequence of the enhanced value of crude oil in 1916, activity was revived in the long-dormant, shallow-sand territory adjacent to Chireno in the southeastern part of Nacogdoches County. New wells drilled in this area ranged in depth between 200 and 900 feet and in capacity up to 30 barrels of oil the first day of productive life.

Central Texas.

Navarro County.—In the old Corsicana and Powell districts activity in drilling was moderate and nothing of consequence was developed. The output of the Corsicana field declined 6 per cent and that of the Powell 9 per cent compared with 1915. In the southern part of the county oil in small quantities was found in shallow wells near Currie.

Williamson County.—Development in the Thrall district in 1916 consisted of routine drilling of inside locations. Production was 29 per cent less than in 1915.

Limestone County.—Active drilling in the Mexia-Groesbeck gas field resulted in the completion of many wells ranging in initial capacity up to 6,000,000 cubic feet of gas a day, and in slight areal additions to the producing territory. Oil is not found in commercial quantities in this district.

Freestone County.—Renewed activity in drilling in the old Wortham district in the northwestern corner of Freestone County furnished a few gas wells of small initial capacity.

Milam County.—Oil in small quantities was found at shallow depths in a few wells drilled near Tracy.

McLennan County.—A 5-barrel oil well was completed in September at a depth of 261 feet on the Prather farm, 4 miles west of Waco.

Unsuccessful tests.—Unsuccessful tests interesting as to location were completed and abandoned in the central part of Texas in 1916 as follows:

Bastrop County.—January—W. H. Champion and others; No. 1 Childress; depth, 2,300 feet. Bastrop Oil & Gas Co.; midway between Bastrop and Smithville; depth, 2,700 feet.

Fayette County.—April—Flatonia Prospect Co.; No. 1 Burke; 3 miles northwest of Flatonia; depth, 1,660 feet.

Travis County.—January—Brown and others; near Austin; depth, 600 feet.

Runnels County.—May—Test near Ballinger; depth, 1,100 feet.

Southern Texas.

Washington County.—Additional drilling in the Mill Creek field, opened in 1915, 8 miles south of Brenham, were disappointing, and at the end of 1916 production was restricted to the discovery well, which produced between 5 and 8 barrels of oil a day when regularly pumped.

Bexar County.—Better success attended developments in the Alta Vista pool opened in 1915, 8 miles south of San Antonio. Although the wells were of small capacity and the oil was accompanied by more

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or less water, this district supported a fair activity throughout the year, interest being gradually transferred to a new locality known as the Van Petty pool, 2 miles farther south, where oil of 36° Baumé gravity was found at shallow depths.

Duval County.—A revival of activity in drilling in the Piedras Pintas district near Benavides resulted in a moderate increase in production, which is obtained from sands found at depths between 300 and 400 feet below the surface. Deep tests were started in the vicinity of the producing wells by both the Cudahy and the Doherty interests.

Unsuccessful tests.—Unsuccessful tests in the stratum division of southern Texas were completed and abandoned in 1916 as follows:

Bee County.—April—Mineral Valley Oil Co.; on Bash lease.
Calhoun County.—August—Edward H. Everett Co.; on Austin farm, 1 mile east of Prague; depth, 3,654 feet.
Cameron County.—January—Brownsville Oil Co., No. 1; 6 miles north of Brownsville; depth, 1,600 feet. June—Brownsville Oil Co., No. 2; 5½ miles north of Brownsville; depth, 3,350 feet.
Colorado County.—March—O. K. Oil & Gas Co.; 4 miles south of Eagle Lake; depth, 1,550 feet.
Gonzales County.—April—Nelson Oil Co.; on Nelson farm, 8 miles from Gonzales; depth, 1,000 feet.
Hidalgo County.—January—Rio Grande Oil Co.; near Mercedes; depth, 2,500 feet.
San Patricio County.—January—Aransas Pass Oil & Development Co.; at Aransas Pass; depth, 1,500 feet. Jones & Buell; at Ingleside; depth, ——— feet.
Uvalde County.—February—Gulf Production Co.; near Uvalde; depth, 2,600 feet.
Webb County.—February—Producers' Oil Co.; No. 1 Matthews; depth, 2,975 feet.

SALT-DOME DIVISION.

The results of drilling in 1916 in the various salt-dome pools of southeastern Texas include 647 oil wells, 28 gas wells, and 355 failures. The average yield of the new oil wells for the first 24 hours of productive life was 600 barrels in 1916, compared with 956 barrels in 1915.

Humble.—The continued success of drilling to the deep sands easily retained for Humble its place of primary importance among the oil fields not only of the Gulf coast region but in the entire State of Texas as well. Of 471 wells completed in 1916 in this pool, 305 produced oil, the average initial yield being 906 barrels each, compared with 106 new oil wells with an average initial yield of 2,517 barrels each in 1915. Aside from a small northward extension of the producing area across San Jacinto River, indicated by a well of moderate production, completed in October on the House tract, the producing area of the Humble pool was not increased during the year. Tests to the west, southwest, and northeast were unsuccessful. To the southeast the discovery in January of encouraging showings of oil and gas at depths between 4,500 and 4,550 feet in a test drilled by Burt & Griffith on the Marshall tract, east of the prolific Stevenson lease, resulted in a test for production that failed to show the value of the find because of inability to shut off the copious flow of water also encountered. A second test was started near this well.

Sourlake.—The production of the Sourlake field in 1916 was 20 per cent greater than in 1915 on account of successful developments in a prolific southward extension of the deep-sand territory demonstrated in April by well No. 1 on the north end of acre 16 of the Merchant subdivision, and on account of the opening of rich territory

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on lands of the Hardin County Oil Co. in the northern part of the field. Well No. 1 of the Yount-Lee Oil Co., on acre 18 of the Merchant tract, completed in October, proved the existence of a new productive sand of much potential importance, reached in this well at a depth of 3,650 feet, about 600 feet below the "deep sand" under development to the north.

Saratoga.—Third rank among the salt-dome pools of Texas was retained in 1916 by Saratoga, despite a decline of nearly 10 per cent in yield, compared with 1915. Outside the territory previously proved productive nothing of consequence was discovered. Deep tests on the Teel lease to the southwest and on the Hopkins lease to the northwest of producing acreage were barren.

Batson.—A gain of 6 per cent in production was credited in 1916 to the Batson pool, which retained fourth place as a consequence of the development work inspired by the discovery in April of a productive sand reached at a depth of about 2,300 feet on the Milholme and Kirby leases, in the northwestern part of the field. The discovery late in December of oil in considerable quantities at a depth of 2,370 feet, in a test on the Prairie lease, drilled by the Paraffine Oil Co., a mile southeast of former production, was interpreted as presaging the development of an important extension.

Goose Creek.—From a position of very minor importance among the salt-dome pools of coastal Texas for several years, Goose Creek rose in the closing months of 1916 to a position of potential importance that ranked it second only to Humble. This transition was a direct consequence of the completion on August 23, by the American Petroleum Corporation, of an 8,000-barrel gusher on the John Gaillard lease, 600 feet in advance of shallow-sand production, in the northwestern part of the field. Although the output of this well declined to about 300 barrels a day before the end of October, it caused a great amount of new drilling, which brought about an increase in the daily output of the pool from about 800 barrels in August to 5,000 barrels in December. with promise of much greater production in 1917.

Spindletop.—But little work was done in the old Spindletop pool and the usual decline, amounting in 1916 to 12 per cent, was recorded.

Matagorda County.—The completion in January of a 1,500-barrel oil well by the Producers Oil Co., in the Markham pool, caused a revival of activity in the old Matagorda County district that resulted in a gain for the year of 20,497 barrels, or 15 per cent, over the output of the pool in 1915. Deep wells for the purpose of thoroughly testing the possibilities of extensions to the south, north, and northeast were under way at the end of 1916.

Efforts to revive Big Hill as a factor in petroleum production resulted in the completion of two barren tests by the Producers Oil Co. at depths of about 2,500 feet. At Bay City, Dr. P. S. Griffith completed a similar test at about 2,800 feet.

Brazoria County.—Interest in drilling in Brazoria County was centered at Damon Mound, in the northwestern part of the county, where, late in December, 1915, oil in moderate quantity was found in a well drilled on the Wisdom tract by the Texas Exploration Co. Active drilling in 1916 resulted in a few barren tests and little real evidence that an important pool had been opened.

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In other parts of this county unsuccessful tests were reported abandoned in 1916 as follows:

March.....Producers Oil Co.; No. 2 Nevins; at Hoskins Mound; depth, 3,031 feet.
W. S. Farish, trustee; No. 1 Seaburn; near Angleton; depth, 2,800 feet.
April.....W. S. Farish, trustee; No. 1 Daunebaum-Tohler; near Angleton; depth, 2,100 feet.
May.....Freeport Sulphur Co.; at Bailey's Prairie; depth, 3,473 feet.
July.....Magnolia Petroleum Co.; No. 1 Retrieve Plantation; 4 miles southwest of Angleton; depth, 3,710 feet.
September.....W. S. Farish, trustee; No. 1 Mooney; near West Columbia; depth, 3,600 feet.
December.....Producers Oil Co.; No. 4 Keiser; near West Columbia; depth, 2,600 feet.
Producers Oil Co.; No. 4 Mound; at Hoskins Mound; depth, 750 feet.
South Dakota-Texas Oil & Development Co.; 6 miles east of Damon Mound; depth, 2,900 feet.

Orange County.—Oil production in Orange County came, in 1916, as in other recent years, from a single well at Terry, the output of which declined 18 per cent. A wildcat test drilled to a depth of 3,640 feet by Hoffman & Turner, on the Forman tract, 4 miles southwest of Orange, failed to disclose evidence of oil or gas and was abandoned at that depth in June.

Liberty County.—Despite the completion of 6 new oil wells in 1916 in the Dayton pool, the production of this old district was 17 per cent less than in 1915.

Unsuccessful wildcat tests of interest in Liberty County were completed as follows:

March....Joint test, Humble Oil Co. and Gulf Production Co.; at Davis Hill; depth, 2,500 feet.
October..Empire Gas & Fuel Co.; No. 1 Abbott; north of Dayton; depth, 3,400 feet.

San Patricio County.—In the Corpus Christi district, on the north side of Nueces Bay, nothing of consequence as far as petroleum is concerned resulted from drilling in 1916. On December 31, 1915, a monster gas well, the initial capacity of which was estimated in excess of 100,000,000 cubic feet, blew itself in on the Gulf Production Co's. White Point lease, about 800 feet north of the similar well completed in 1914. This well was capped the first week of January, 1916, but broke its heavy fittings on January 12, and ran wild for several days. On January 17 it caught fire and for nearly two months burned fiercely, forming about its mouth, as in the case of its predecessor, a seething crater of water, mud, and burning gas, that engulfed the remnants of the drilling rig and eventually choked the hole.

The third well on this lease, half a mile to the west, came in on July 16, with an estimated initial capacity of 20,000,000 cubic feet of gas under a rock pressure of 600 pounds. After blowing dry gas for a few days this well was capped and, when opened later in July, was found to have gone to salt water, barely enough gas being available for additional drilling in the locality. Other tests were under way at the end of 1916.

After running wild for more than a year well No. 1 of the Gulf Coast Oil & Gas Co., on the Kirk tract, 2 miles east of No. 1 White Point, was finally brought under control in December, 1916.

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Unsuccessful tests in the general vicinity of Corpus Christi were completed as follows:

April..Walker, Clarkson, and others; at Flour Bluff; 9 miles south of Corpus Christi; depth, 2,300 feet.
May..Pioneer Oil Co.; No. 1 Dunn; 4 miles west of Corpus Christi; depth, 3,300 feet.

Unsuccessful tests.

Unsuccessful tests of interest because of their location were completed and abandoned in other sections of the salt-dome division in 1916 as follows:

Chambers County.—January—Dome Oil Co.; 12 miles northwest of Stowell; depth, 1,400 feet. June—Staiti and others; No. 1 Fisher; at Barbers Hill; depth, 1,410 feet. July—Joint test of Humble Oil Co. and Gulf Production Co.; on Collier tract at Barbers Hill; depth, 3,150 feet. October—W. W. Collins and others; 4 miles northwest of Wallisville; depth, 1,825 feet. December—Glenn Oil & Mineral Co.; 9 miles north of Anahuac; depth, 2,000 feet.

Hardin County.—December—Magdalene Oil Co.; on Lopez tract, 2 miles north of Batson; depth, 3,906 feet.

Harris County.—July—Producers Oil Co.; No. 1 Martin; 4 miles south of Hockley; depth, 3,100 feet. October—Henderson and others; San Jacinto Rice Co's. plantation; depth, 3,400 feet.

Jasper County.—November—C. C. Codman and others; near Thorpe; depth, 3,500 feet.

Montgomery County.—July—Callahan Oil Co.; on fee, north of Humble; depth, 3,250 feet. October—Magnolia Petroleum Co.; 2 miles south of Montgomery; depth, 2,100 feet. December—Pierce-Fordyce Oil Association; on Minick lease, south of Conroe; depth, 3,600 feet.

Rusk County.—March—Snowden Bros.; No. 1 Frambrough; 2½ miles south of Kilgore; depth, 3,500 feet.

MARKETED PRODUCTION.

Petroleum marketed in Texas, 1907–1916, in barrels.

Year.	Northern Texas.									Coastal Texas.	
	Corsicana.	Powell.	Petrolia (Henrietta).	Marion County.	Wichita County.	Moran.	Thrall.	Other.	Total.	Spindletop.	Saratoga.
1907	226,311	596,897	83,260	.....	.....	.....	.....	6,150	912,618	1,699,943	2,130,928
1908	211,117	421,659	85,963	.....	.....	.....	.....	4,525	723,264	1,747,537	1,634,786
1909	180,764	383,137	113,485	.....	.....	.....	.....	4,554	681,940	1,388,107	1,183,559
1910	137,331	450,188	126,531	251,717	.....	.....	.....	3,636	969,403	1,182,436	1,024,348
1911	128,526	373,055	168,965	677,689	899,579	.....	.....	3,379	2,251,193	965,939	925,777
1912	233,282	251,240	197,421	362,870	4,227,104	.....	.....	3,590	5,275,507	822,916	1,116,655
1913	158,830	282,476	344,868	262,392	8,131,624	.....	.....	4,062	9,184,252	716,374	937,720
1914	133,811	282,279	550,585	180,584	8,227,968	68,191	.....	7,704	9,451,122	580,130	899,743
1915	143,275	237,410	349,857	123,464	5,833,951	109,016	613,182	63,398	7,473,553	388,266	864,266
1916	135,263	215,729	302,145	64,971	7,837,386	135,608	432,695	179,208	9,303,005	340,441	781,128

Year.	Coastal Texas—Continued.									Total.
	Sourlake.	Matagorda County.	Batson.	Humble.	Dayton.	Goose Creek.	Orange County.	Other.	Total.	
1907	2,353,940	1,573	2,164,453	2,929,640	108,038	.....	.....	21,563	11,410,078	12,322,606
1908	1,595,060	62,640	1,593,570	3,778,521	39,901	.....	.....	31,185	10,483,200	11,206,464
1909	1,703,798	29,103	1,206,214	3,237,060	17,647	.....	.....	87,039	8,852,527	9,534,467
1910	1,518,723	455,999	1,113,767	2,495,511	9,582	.....	.....	129,497	7,929,863	8,899,266
1911	1,364,880	561,828	1,023,493	2,426,220	4,344	.....	.....	2,800	7,275,281	9,526,474
1912	1,175,108	613,292	844,563	1,829,923	12,151	43,898	.....	1,044	6,459,550	11,735,057
1913	1,348,053	294,553	741,350	1,504,880	13,329	249,641	17,706	1,620	5,825,226	15,009,478
1914	5,209,208	164,192	775,804	2,799,458	18,791	134,748	43,208	1,780	10,617,062	20,068,184
1915	4,114,622	137,841	703,686	11,061,802	10,378	119,336	21,697	47,254	17,469,148	24,942,701
1916	4,923,332	158,338	744,915	10,925,806	8,571	397,391	17,758	43,921	18,341,600	27,644,606

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Petroleum marketed in Texas, 1907–1916.

Year.	Northern Texas.		Coastal Texas.		Total.	
	Quantity (barrels).	Value.	Quantity (barrels).	Value.	Quantity (barrels).	Value.
1907	912,618	$721,577	11,410,078	$9,680,286	12,322,696	$10,401,863
1908	723,284	479,072	10,483,200	6,221,636	11,206,484	6,700,708
1909	681,940	393,732	8,852,527	6,399,318	9,534,467	6,793,050
1910	969,403	505,396	7,929,963	6,100,359	8,899,366	6,605,755
1911	2,251,193	1,213,960	7,275,281	5,340,592	9,526,474	6,554,552
1912	5,275,507	4,112,815	6,459,550	4,739,898	11,735,057	8,852,713
1913	9,184,252	9,125,185	5,825,226	5,550,408	15,009,478	14,675,593
1914	9,451,122	7,778,456	10,617,062	7,164,393	20,068,184	14,942,848
1915	7,473,553	4,656,934	17,469,148	8,369,991	24,942,701	13,026,925
1916	9,303,005	11,834,973	18,341,600	13,925,362	27,644,605	25,760,335

Petroleum marketed in Texas in 1915 and 1916, by districts, with increase or decrease.

District.	1915			1916			Increase or decrease.	
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Barrels.	Per cent.
Northern Texas:								
Corsicana	143,275	$106,582	$0.744	135,263	$167,967	$1.242	− 8,012	− 5.59
Marion County	123,464	88,079	.713	64,971	80,305	1.236	− 58,493	− 47.38
Moran	109,016	78,147	.717	135,608	180,666	1.332	+ 26,592	+ 24.39
Petrolia	349,857	220,965	.632	302,145	419,043	1.387	− 47,712	− 13.64
Powell	237,410	106,552	.449	215,729	136,147	.631	− 21,681	− 9.13
Thrall	613,182	345,482	.563	432,695	523,898	1.211	− 180,487	− 29.43
Wichita County	5,833,951	3,662,794	.628	7,837,386	10,095,423	1.288	+2,003,435	+ 34.34
Other	63,398	48,343	.763	179,208	231,524	1.292	+ 115,810	+182.67
	7,473,553	4,656,934	.623	9,303,005	11,834,973	1.272	+1,829,452	+ 24.48
Coastal Texas:								
Batson	703,686	323,875	.403	744,915	552,116	.741	+ 41,229	+ 5.86
Dayton	10,378	4,841	.466	8,571	6,419	.749	− 1,807	− 17.41
Goose Creek	119,336	61,508	.515	397,391	292,537	.736	+ 278,055	+233.00
Humble	11,061,802	5,329,055	.482	10,925,805	8,369,072	.766	− 135,997	− 1.23
Matagorda County	137,841	70,300	.510	158,338	109,999	.695	+ 20,497	+ 14.87
Orange County	21,697	13,351	.615	17,758	11,892	.670	− 3,939	− 18.15
Saratoga	864,266	440,409	.510	781,128	566,889	.726	− 83,138	− 9.62
Sourlake	4,111,622	1,894,403	.460	4,923,332	3,715,157	.755	+ 808,710	+ 19.65
Spindletop	388,266	191,134	.492	340,441	269,269	.791	− 47,825	− 12.32
Other	47,254	41,115	.870	43,921	32,012	.729	− 3,333	− 7.05
	17,469,148	8,369,991	.479	18,341,600	13,925,362	.759	+ 872,452	+ 4.99
Total Texas	24,942,701	13,026,925	.522	27,644,605	25,760,335	.932	+2,701,904	+ 10.83

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Petroleum marketed in Texas in 1915 and 1916, in barrels.

1915.

Month.	Northern Texas.									Coastal Texas.	
	Corsicana.	Marion County.	Moran.	Petrolia (Henrietta).	Powell.	Thrall.	Wichita County.	Other.a	Total.	Batson.	Dayton.
January	12,805	11,074	7,630	26,754	22,486	.....	555,889	1,026	637,664	63,587	828
February	12,356	12,157	5,961	25,120	21,390	.....	496,407	1,026	574,417	56,329	1,720
March	12,142	11,888	7,239	32,453	21,504	2,157	534,608	1,026	623,017	60,624	996
April	11,247	11,009	5,420	30,896	21,636	94,071	502,221	1,026	677,526	62,735	1,363
May	12,351	11,597	6,407	34,392	20,983	116,431	504,839	7,366	714,366	62,597	767
June	11,904	10,724	5,426	29,205	20,478	114,269	473,932	8,874	674,812	59,277	580
July	11,948	10,985	5,555	31,877	19,871	73,613	480,997	9,101	643,947	59,685	259
August	10,379	9,866	12,812	28,144	17,546	60,297	474,717	7,440	621,201	52,814	835
September	11,158	9,193	15,095	26,903	18,648	47,504	449,395	6,014	583,910	53,682	686
October	10,685	8,684	13,313	27,484	16,650	42,627	456,524	7,397	583,364	62,121	1,060
November	14,586	8,092	12,034	28,015	18,102	35,321	439,736	6,451	562,337	55,345	855
December	11,714	8,195	12,124	28,614	18,116	26,892	464,686	6,651	576,992	54,890	429
	143,275	123,464	109,016	349,857	237,410	613,182	5,833,951	63,398	7,473,553	703,686	10,378

Month.	Coastal Texas—Continued.									Total.
	Goose Creek.	Humble.	Matagorda County.b	Orange County.	Saratoga.	Sourlake.	Spindletop.	Other.c	Total.	
January	12,464	344,694	11,844	2,239	75,342	402,311	39,617	129	953,055	1,590,719
February	10,033	615,122	10,356	2,266	73,419	346,566	36,811	129	1,152,751	1,727,168
March	13,579	620,966	11,244	2,163	78,458	370,284	36,595	129	1,195,038	1,818,055
April	9,799	590,914	12,574	2,273	75,656	349,043	38,607	129	1,143,093	1,820,619
May	10,188	470,514	10,767	2,263	73,697	358,821	34,469	129	1,024,212	1,738,578
June	9,568	585,813	13,302	1,198	75,149	323,479	31,031	129	1,099,526	1,774,338
July	10,253	786,457	12,275	1,379	79,390	334,140	30,374	129	1,314,341	1,958,288
August	5,318	784,374	7,541	1,790	65,900	265,616	24,750	3,929	1,212,867	1,834,068
September	8,587	1,149,746	9,302	1,617	68,829	305,977	26,751	6,309	1,631,486	2,215,396
October	11,096	1,612,448	11,993	1,848	67,752	338,734	30,508	8,789	2,146,349	2,729,713
November	7,507	2,067,268	9,513	817	66,064	326,296	29,279	12,058	2,575,022	3,137,359
December	10,944	1,433,486	17,130	1,844	64,590	393,355	29,474	15,266	2,021,408	2,598,400
	119,336	11,061,802	137,841	21,697	864,266	4,114,622	388,266	47,254	17,469,148	24,942,701

1916.

Month.	Northern Texas.									Coastal Texas.	
	Corsicana.	Marion County.	Moran.	Petrolia (Henrietta).	Powell.	Thrall.	Wichita County.	Other.a	Total.	Batson.	Dayton.
January	10,518	8,256	12,540	31,051	15,939	51,953	473,437	8,020	611,714	53,383	576
February	11,391	7,750	9,723	31,642	16,599	50,656	464,482	10,908	603,151	52,111	446
March	12,254	6,021	15,968	30,696	17,549	51,361	539,451	18,435	691,735	51,553	450
April	13,654	5,483	14,927	26,613	16,805	44,523	569,600	24,823	716,428	50,985	395
May	11,742	5,527	14,969	28,785	19,688	41,199	667,948	22,913	812,771	56,005	1,073
June	11,417	5,269	13,674	26,035	19,538	39,932	722,835	18,293	856,998	61,235	1,681
July	11,259	5,005	13,065	19,819	17,793	34,395	767,795	20,260	889,391	58,415	611
August	11,028	4,917	9,905	22,258	19,071	30,732	754,540	12,387	864,838	71,199	884
September	11,220	4,172	9,456	21,802	18,205	24,270	709,855	11,763	810,743	70,563	423
October	10,907	4,446	8,179	23,348	17,833	24,142	742,781	9,432	841,068	78,557	626
November	9,711	4,097	6,630	20,198	18,967	18,306	714,022	8,561	800,492	69,086	709
December	10,162	4,028	6,572	19,898	17,742	21,226	710,640	13,413	803,681	71,823	697
	135,253	64,971	135,608	302,145	215,729	432,695	7,837,386	179,208	9,303,005	744,915	8,571

a Includes Archer, Jack, and McLennan counties and the Strawn pool.
b Markham and Big Hill.
c Includes Bexar, Duval, McMullen, Nacogdoches, and Washington counties.

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Petroleum marketed in Texas in 1915 and 1916, in barrels—Continued.

1916—Continued.

Month.	Coastal Texas—Continued.									Total.
	Goose Creek.	Humble.	Matagorda County.[b]	Orange County.	Saratoga.	Sour lake.	Spindletop.	Other.[c]	Total.	
January	6,315	1,402,531	15,297	1,923	69,619	343,754	28,040	1,664	1,923,102	2,534,816
February	13,345	1,189,659	9,570	1,541	66,344	323,698	25,873	1,502	1,684,069	2,287,240
March	13,551	1,114,883	12,407	1,777	71,665	337,650	28,786	1,977	1,634,699	2,326,434
April	11,136	960,770	9,734	1,826	64,479	350,560	30,911	2,075	1,482,871	2,199,299
May	10,086	1,072,850	10,816	1,619	68,094	418,897	28,216	2,179	1,669,835	2,482,606
June	13,777	878,090	24,987	1,856	61,794	425,587	30,291	3,592	1,492,890	2,349,883
July	17,946	781,212	14,990	1,796	61,756	451,033	28,607	3,993	1,420,359	2,309,750
August	21,425	795,785	13,314	1,862	68,384	402,481	29,792	3,769	1,408,895	2,273,733
September	67,516	720,869	12,985	1,678	64,853	382,273	28,254	5,237	1,354,651	2,165,394
October	54,017	718,873	11,878	249	64,335	434,580	29,059	6,196	1,408,370	2,249,438
November	55,540	625,435	11,676	786	60,217	413,064	25,868	5,801	1,268,182	2,068,674
December	112,737	664,848	10,684	845	59,588	639,755	26,744	5,936	1,593,657	2,397,338
	397,391	10,925,805	158,338	17,758	781,128	4,923,332	340,441	43,921	18,341,600	27,644,605

[a] Markham and Big Hill.
[b] Includes Bexar, Duval, McMullen, Nacogdoches, and Washington counties.

SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources, and differ somewhat from those on pages 708–709, obtained from reports received directly from the oil producers:

Wells completed in central and northern Texas, 1912–1916.

District.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Archer County					2					1					3
Coleman County					5					1					7
Corsicana[b]	17	3	10	1	2	7	1	5			24	4	15	1	2
Jack County				2	1					2				2	3
Marion County	3	16	8	13	7	7	6	2	5	9	10	22	10	18	16
Moran		1	3	9	2		4	3	12	4		6	12	21	6
Panola County					1					1					3
Petrolia[c]	6	122	80	4	6	10	45	32	1	3	20	171	126	8	17
Stephens County					2					1					4
Strawn[d]				40	51				35	27				89	98
Thrall[e]				112	49				103	15				216	64
Wichita County	259	435	394	124	372	66	125	169	29	65	325	561	567	156	441
Wilbarger County				1										1	1
Young County				1										1	
Miscellaneous	14	4	2			34	27	10	13	16	54	35	14	15	18
Coastal and southern Texas	299	581	497	307	500	124	208	221	198	183	434	799	744	528	683
	353	325	323	306	647	109	255	130	230	255	462	592	464	541	1,030
Total Texas	652	906	820	613	1,147	233	463	351	428	500	896	1,391	1,208	1,069	1,713

[a] Including gas wells.
[b] Including Powell.
[c] Including Henrietta.
[d] Including other tests in Palo Pinto County.
[e] Including other tests in Williamson County.

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Oil wells and dry holes drilled in central and northern Texas in 1916.

District.	January.		February.		March.		April.		May.		June.		July.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Archer County														
Coleman County			1		1									
Corsicana [a]			1		1									
Jack County						2								
Marion County	1		2			1	2		1	2	1	1		1
Moran									2	4				
Panola County														
Petrolia [b]	2						1		1					
Stephens County													1	
Strawn	3	5	8	3	2	3	3	1	2	2	5	3	2	2
Thrall	11	1	7	3	4	1	7	3	5		8	5	5	2
Wichita County	17	2	25	2	29	7	41	6	45	4	48	4	33	10
Miscellaneous		4				2		1		1		1		2
Coastal and southern Texas.	34	12	44	8	37	16	54	11	56	13	62	14	41	17
	41	27	47	32	66	25	74	29	90	48	57	36	56	33
Total Texas	75	39	91	40	103	41	128	40	146	61	119	50	97	50

District.	August.		September.		October.		November.		December.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Archer County			1	1					1		2	1
Coleman County					1	1			2		5	1
Corsicana [a]											2	
Jack County	1										1	2
Marion County		1		1		1		1			7	9
Moran											2	4
Panola County	1			1							1	1
Petrolia [b]	1	1	1	1						1	6	3
Stephens County					1			1			2	1
Strawn	4	3	6	3	2	2	8		6		51	27
Thrall	2										49	15
Wichita County	15	4	32	7	27	6	30	6	30	7	372	65
Miscellaneous				2		2				1		16
Coastal and southern Texas.	24	9	40	16	31	12	38	8	39	9	500	145
	49	29	39	26	37	15	39	26	52	29	647	355
Total Texas	73	38	79	42	68	27	77	34	91	38	1,147	500

[a] Including Powell. [b] Including Henrietta.

Wells completed in central and northern Texas, 1912–1916.

Month.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
January	4	38	64	14	34		27	24	6	12	4	66	89	20	49
February	21	31	49	22	44	3	25	23	9	8	24	57	74	31	55
March	22	35	95	20	37	8	12	39	7	16	31	47	138	28	59
April	33	55	79	34	54	8	16	22	17	11	44	73	106	53	69
May	38	57	46	37	56	11	18	26	28	13	49	76	73	66	75
June	12	61	44	30	62	19	19	14	31	14	31	80	60	63	79
July	20	47	23	12	41	12	17	18	13	17	32	66	42	29	60
August	34	56	29	29	24	18	20	11	22	9	53	77	42	52	37
September	22	41	16	23	40	8	9	6	15	16	32	50	25	39	58
October	44	48	20	19	31	10	10	18	16	12	55	59	40	37	44
November	22	68	22	33	38	19	25	12	16	8	42	93	36	55	47
December	27	44	10	34	39	8	10	8	18	9	37	55	19	55	51
	299	581	497	307	500	124	208	221	198	145	434	799	744	528	683

[a] Including gas wells.

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Initial daily production of new wells completed in central and northern Texas in 1916, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Archer County									35			25	60
Coleman County		15	25							50		60	150
Corsicana [a]		15	5										20
Jack County								2					2
Marion County	450	95		75	40	75							735
Moran					40								40
Panola County								15					15
Petrolia [b]	175			25	20			60	5				285
Stephens County							35			70			105
Strawn	80	310	90	300	50	225	115	100	185	95	285	175	2,010
Thrall	400	735	555	110	120	53	55	25					2,053
Wichita County	1,435	1,614	2,444	3,658	4,539	10,488	9,736	1,725	2,111	1,594	4,018	891	44,253
	2,540	2,784	3,119	4,168	4,809	10,841	9,941	1,927	2,336	1,809	4,303	1,151	49,728
Coastal and southern Texas	49,515	55,732	60,959	24,008	56,020	36,580	14,149	10,834	11,970	23,425	12,580	32,650	388,422
Total Texas	52,055	58,516	64,078	28,176	60,829	47,421	24,090	12,761	14,306	25,234	16,883	33,801	438,150

[a] Including Powell. [b] Including Henrietta.

Total and average initial daily production of new wells in central and northern Texas, 1912–1916, by districts, in barrels.

District.	Total initial production.					Average per well.				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Archer County					60					30.0
Coleman County					150					30.0
Corsicana [a]	108	12	23	2	20	6.4	4.0	2.3	2.0	10.0
Jack County				15	2				7.5	2.0
Marion County	198	5,250	390	1,445	735	66.0	328.1	48.8	111.2	105.0
Moran		200	690	995	40		40.0	210.0	110.6	20.0
Panola County					15					15.0
Petrolia [b]	315	2,676	1,958	273	285	52.5	21.9	24.5	68.3	47.5
Stephens County					105					52.5
Strawn				1,245	2,010				31.1	39.4
Thrall				43,170	2,053				385.4	41.9
Wichita County	26,932	49,286	21,917	5,488	44,253	104.0	113.3	55.6	44.3	119.0
Wilbarger County				10					10.0	
Young County				20					20.0	
Other	660	11	25			47.1	2.2	12.5		
	28,213	57,435	25,003	52,663	49,728	94.3	98.9	50.3	171.5	99.5
Coastal and southern Texas	33,082	38,978	160,695	292,541	388,422	93.7	119.9	497.5	966.0	600.3
Total Texas	61,295	96,413	185,698	345,204	438,150	94.0	106.4	226.4	563.1	382.0

[a] Including Powell. [b] Including Henrietta.

Total initial daily production of new wells in central and northern Texas, 1912–1916, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1912	650	3,395	3,185	2,004	2,955	955	1,909	2,462	2,250	5,006	1,678	1,764	28,213	2,351
1913	2,726	3,366	2,986	1,909	6,258	9,720	7,391	4,593	5,605	5,092	5,291	2,498	57,435	4,786
1914	5,401	4,217	3,785	2,731	2,306	2,229	965	1,133	1,184	261	622	164	25,003	2,084
1915	507	1,300	6,250	9,558	11,365	9,940	4,455	3,655	1,720	785	1,748	1,380	52,663	4,389
1916	2,540	2,784	3,119	4,168	4,809	10,841	9,941	1,927	2,336	1,809	4,303	1,151	49,728	4,144

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Wells completed in coastal and southern Texas, 1912–1916.

District.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Batson	23	51	51	36	75	7	16	9	7	16	30	69	60	43	92
Bexar County	.....	.....	.....	5	6	.....	.....	.....	1	4	.....	.....	.....	6	10
Brazoria County	.....	.....	.....	.....	2	.....	.....	.....	.....	14	.....	.....	.....	.....	17
Chambers County	.....	.....	.....	.....	1	.....	.....	.....	2	4	.....	.....	.....	2	5
Dayton	.....	.....	2	1	6	.....	.....	.....	7	13	.....	.....	2	8	19
Duval County	.....	.....	.....	3	6	.....	.....	.....	.....	1	.....	.....	.....	3	8
Goose Creek	17	27	34	6	42	9	24	10	5	15	26	51	44	11	60
Humble	90	89	46	106	305	27	54	33	69	150	117	144	80	176	471
Matagorda County	31	8	1	8	12	17	13	.....	.....	11	48	21	4	8	23
Nacogdoches County	.....	.....	.....	.....	1	.....	.....	.....	.....	1	.....	.....	.....	.....	2
Orange County	.....	.....	3	.....	.....	.....	.....	5	5	3	.....	.....	8	5	3
Saratoga	91	49	17	34	55	11	28	4	11	12	102	78	21	45	67
Sourlake	54	64	140	93	114	8	18	44	52	32	62	85	184	146	146
Spindletop	47	29	24	11	22	30	40	7	3	13	77	69	32	14	35
Washington County	.....	.....	.....	2	.....	.....	.....	.....	1	4	.....	.....	.....	4	4
Wilson County	.....	.....	.....	1	.....	.....	.....	.....	1	.....	.....	.....	.....	2	.....
Miscellaneous	.....	8	5	.....	.....	.....	62	18	66	62	.....	75	29	68	68
Central and northern Texas	353	325	323	306	647	109	255	130	230	355	462	592	464	541	1,080
	299	581	497	307	500	124	208	221	198	145	434	799	744	528	683
Total Texas	652	906	820	613	1,147	233	463	351	428	500	896	1,391	1,208	1,069	1,713

[a] Including gas wells.

Oil wells and dry holes drilled in coastal and southern Texas in 1916.

District.	January.		February.		March.		April.		May.		June.		July.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Batson	3	.....	4	1	6	1	11	.....	5	.....	6	2	7	2
Bexar County	.....	.....	2	.....	2	2	2	1	.....	.....	.....	1	.....	.....
Brazoria County	.....	.....	.....	.....	.....	2	.....	.....	.....	1	.....	1	1	1
Chambers County	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1
Dayton	.....	.....	.....	2	.....	.....	.....	1	.....	.....	2	1	2	1
Duval County	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....
Goose Creek	.....	1	1	1	1	2	3	.....	3	.....	5	1	2	2
Humble	24	13	25	14	43	7	30	15	57	32	27	16	25	16
Matagorda County	.....	.....	.....	.....	1	2	2	.....	5	.....	1	2	1	1
Nacogdoches County	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....
Orange County	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....
Saratoga	5	2	3	4	4	2	10	2	8	1	4	.....	4	1
Sourlake	6	1	8	.....	7	2	13	2	10	5	8	1	13	1
Spindletop	.....	.....	4	.....	2	2	3	1	2	2	2	.....	1	3
Washington County	.....	.....	.....	1	.....	.....	.....	1	.....	1	.....	1	.....	.....
Miscellaneous	.....	10	.....	9	.....	3	.....	6	.....	6	.....	7	.....	4
Central and northern Texas	41	27	47	32	66	25	74	29	90	48	57	36	56	33
	34	12	44	8	37	16	54	11	56	13	62	14	41	17
Total Texas	75	39	91	40	103	41	128	40	146	61	119	50	97	50

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Oil wells and dry holes drilled in coastal and southern Texas in 1916—Continued.

District.	August.		September.		October.		November.		December.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Batson	11	1	9	1	3	3	4	4	6	1	75	16
Bexar County	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6	4
Brazoria County	1	2	.....	3	.....	2	.....	2	.....	.....	2	14
Chambers County	.....	.....	.....	.....	.....	.....	.....	1	.....	1	1	4
Dayton	1	2	1	2	.....	3	.....	.....	.....	1	6	13
Duval County	.....	.....	.....	.....	2	.....	.....	.....	1	1	6	1
Goose Creek	2	1	1	1	2	.....	9	4	13	2	42	15
Humble	17	8	16	13	15	2	10	7	16	7	305	150
Matagorda County	1	3	.....	1	1	.....	.....	1	.....	1	12	11
Nacogdoches County	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	1	1
Orange County	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	3
Saratoga	4	.....	4	.....	1	.....	4	.....	4	.....	55	12
Sourlake	9	3	6	.....	11	3	11	5	12	9	114	32
Spindletop	3	2	2	.....	2	.....	1	1	.....	2	22	13
Washington County	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
Miscellaneous	.....	6	.....	4	.....	2	.....	1	.....	4	.....	62
	49	29	39	26	37	15	39	26	52	29	647	355
Central and northern Texas	24	9	40	16	31	12	38	8	39	9	500	145
Total Texas	73	38	79	42	68	27	77	34	91	38	1,147	500

Wells completed in coastal and southern Texas, 1912–1916.

Month.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
January	13	26	38	22	41	8	6	3	11	27	21	34	42	33	73
February	41	25	18	25	47	8	18	4	4	32	49	43	24	29	81
March	35	32	22	17	66	8	16	7	15	25	43	49	29	32	91
April	45	33	20	15	74	13	30	18	18	29	58	66	39	33	105
May	24	20	37	24	90	13	15	8	13	48	37	38	47	37	143
June	25	31	27	30	57	10	31	10	32	36	35	65	37	62	96
July	23	36	37	25	56	8	27	18	34	33	31	6.	56	60	91
August	30	31	32	26	49	9	30	20	17	29	39	61	54	44	80
September	27	25	21	32	39	10	20	8	23	28	37	45	30	55	67
October	38	23	23	20	37	8	21	16	11	15	46	44	39	31	52
November	34	19	26	37	39	5	16	13	28	26	39	35	40	66	68
December	18	24	22	33	52	9	25	5	24	29	27	49	27	59	83
	353	325	323	306	647	109	255	130	230	355	462	592	464	541	1,030

[a] Including gas wells.

Initial daily production of new wells completed in coastal and southern Texas in 1916, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Batson	50	40	94	1,690	80	3,550	1,020	3,100	540	270	380	665	11,479
Bexar County	.....	75	220	95	.....	.....	.....	.....	.....	.....	.....	.....	390
Brazoria County	.....	.....	.....	.....	.....	.....	10	4	.....	.....	.....	.....	14
Chambers County	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10
Dayton	.....	.....	.....	.....	.....	90	14	10	20	.....	.....	.....	134
Duval County	170	.....	.....	.....	.....	150	.....	.....	.....	40	.....	25	385
Goose Creek	.....	50	400	265	900	735	225	1,650	400	2,600	6,925	9,100	23,250
Humble	44,900	53,095	57,675	18,240	50,770	20,390	3,485	1,740	8,020	9,785	1,520	6,735	276,355
Matagorda County	.....	.....	10	135	215	5,000	75	25	.....	60	.....	.....	5,520
Nacogdoches County	.....	.....	.....	.....	.....	10	.....	.....	.....	.....	.....	.....	10
Saratoga	110	100	105	188	360	95	415	320	40	20	80	265	2,098
Sourlake	4,275	2,325	2,415	3,330	3,460	6,500	8,900	3,815	2,775	10,550	3,650	15,860	67,855
Spindletop	.....	47	40	65	235	60	5	170	175	100	25	.....	922
	49,515	55,732	60,959	24,008	56,020	36,580	14,149	10,834	11,970	23,425	12,580	32,650	388,422
Central and northern Texas	2,540	2,784	3,119	4,168	4,809	10,841	9,941	1,927	2,336	1,809	4,303	1,151	49,728
Total Texas	52,055	58,516	64,078	28,176	60,829	47,421	24,090	12,761	14,306	25,234	16,883	33,801	438,150

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Total and average initial daily production of new wells in coastal and southern Texas, 1912–1916, by districts, in barrels.

District.	Total initial production.					Average per well.				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Batson	829	5,980	2,191	931	11,479	36.0	117.3	43.0	25.9	153.1
Bexar County	.....	.....	.....	185	390	.....	.....	.....	37.0	65.0
Brazoria County	.....	.....	.....	.....	14	.....	.....	.....	.....	7.0
Chambers County	.....	.....	.....	.....	10	.....	.....	.....	.....	10.0
Dayton	.....	.....	400	20	134	.....	.....	200.0	20.0	22.3
Duval County	.....	.....	.....	80	385	.....	.....	.....	26.7	64.2
Goose Creek	3,005	3,130	2,375	710	23,250	176.8	115.9	69.9	118.3	553.6
Humble	5,615	8,119	22,842	266,830	276,355	62.3	91.2	496.6	2,517.3	906.1
Matagorda County	10,040	390	25	2,375	5,520	323.8	47.5	25.0	296.8	460.0
Nacogdoches County	.....	.....	.....	.....	10	.....	.....	.....	.....	10.0
Orange County	.....	.....	350	.....	.....	.....	.....	116.7	.....	.....
Saratoga	9,350	7,883	900	2,510	2,098	102.7	160.9	52.9	73.8	38.1
Sourlake	1,530	11,443	130,341	18,695	67,855	28.3	178.8	931.0	201.0	595.2
Spindletop	2,713	1,778	1,191	160	922	57.7	61.3	49.6	14.5	41.9
Washington County	.....	.....	.....	40	.....	.....	.....	.....	20.0	.....
Wilson County	.....	.....	.....	5	.....	.....	.....	.....	5.0	.....
Miscellaneous	.....	265	80	.....	.....	.....	33.1	16.0	.....	.....
Central and northern Texas	33,082	38,978	160,695	292,541	388,422	93.7	119.9	497.5	956.0	600.3
	28,213	57,435	25,003	52,663	49,728	94.3	98.9	50.3	171.5	99.5
Total Texas	61,295	96,413	185,698	345,204	438,150	94.0	106.4	226.4	563.1	382.0

Total initial daily production of new wells in coastal and southern Texas, 1912–1916, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1912	935	5,495	3,359	3,435	875	1,805	5,265	2,038	6,055	1,080	1,259	1,481	33,082	2,757
1913	1,147	3,652	10,936	2,305	5,595	3,195	1,335	1,147	1,757	2,186	1,016	4,707	38,978	3,248
1914	5,026	3,696	20,075	25,249	12,816	16,907	15,923	12,823	12,773	12,320	14,172	8,915	160,695	13,391
1915	15,180	14,458	3,385	3,300	11,220	12,640	13,475	13,880	36,133	61,030	88,100	19,740	292,541	24,378
1916	49,515	55,732	60,959	24,008	56,020	36,580	14,149	10,834	11,970	23,425	12,580	32,650	388,422	32,369

LOUISIANA.

GENERAL STATEMENT.

The output of petroleum from Louisiana in 1916 was less by 2,943,401 barrels, or 16 per cent, than the record output in 1915. It amounted to 15,248,138 barrels, of which 11,821,642 barrels, or 78 per cent, came from the oil districts of northern Louisiana and 3,426,496, or 22 per cent, came from the saline-dome pools of southern Louisiana. Compared with 1915, the output of the northern or stratum division was less by 3,260,392 barrels, or 22 per cent, whereas that of the southern or salt-dome division was greater by 316,991 barrels, or 10 per cent. All districts in the northern division shared in the decline from 1915 noted—Caddo falling off 16 per cent; De Soto, 8 per cent; Red River, 31 per cent; and Sabine, 11 per cent. The gain in the southern division was divided between Vinton and Jennings, the other pools, Edgerly, Welsh, and Anse la Butte falling below their output in 1915.

Market conditions were in general more favorable in 1916 than in 1915. The average price received for oil at the wells in Louisiana in 1916 was $1.03 a barrel for the product of the northern division and

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73 cents a barrel for that of the southern division, these prices being, respectively, 41 cents and 27 cents higher than the average prices in 1915.

DEVELOPMENT.

As indicated by the statistics of wells completed, drilling activity in Louisiana was 18 per cent greater in 1916 than in 1915. In all, 666 new wells were completed in the entire State in 1916. Of these 428, or 64 per cent, were oil wells credited with an average flow of 388 barrels of oil each the first 24 hours after completion; 56, or 8 per cent, were gas wells; and 182, an average of 3 in every 11, were failures. The average initial capacity of all oil wells completed in the State in 1916 was 33 per cent less than in 1915. This decrease was entirely in the northern division, where the average initial capacity of new wells was 70 per cent lower than in 1915, owing to the exhaustion of flush production in the Crichton field, Red River Parish, and to the failure to complete the usual number of wells of large capacity in the Caddo district. Because of the completion of a number of wells of large capacity in the Vinton pool in 1916 the average initial output of new wells in the southern division was 73 per cent greater than in 1915.

NORTHERN OR STRATUM DIVISION.

Caddo district.—In the pioneer district of northern Louisiana the most important results of drilling in 1916 were obtained in the south-central part of T. 20 N., R. 16 W., in the area west of Mooringsport. Development in this locality, which had been proceeding for some time in a desultory fashion on the Hunter and adjoining leases, in sec. 32, received a decided impulse in April by the completion of an 800-barrel well on the Green lease in sec. 27 by the Amateur Oil Co., 1½ miles northeast of the Hunter wells. Other wells ranging in initial capacities from 100 to 500 barrels were completed subsequently in this locality and before the end of 1916 the new development had spread out over the greater part of secs. 27, 33, 34, and 35, T. 20 N., R. 16 W.

New territory of promise was opened late in 1916 east of Mooringsport by the completion of productive wells on the Hammitt and Nunneley leases, in the eastern part of sec. 27, T. 20 N., R. 15 W. Drilling in other parts of the Caddo district led to no important additions to proved territory.

Interest in the development of the Shreveport gas district in the southern part of Caddo Parish led to the completion of many gas wells of large capacity in the Harts Island locality south of Shreveport, the Cross Lake locality west of it, and the Blanchard locality northwest of it.

De Soto district.—The completion in February of a 3,000-barrel oil well on the Saunders lease, in sec. 34, T. 13 N., R. 12 W., within the proved limits of the Naborton pool caused a revival of activity in the eastern part of De Soto Parish. The subsequent blowing in as a 2,000-barrel oil well of an abandoned gas well, in sec. 25, T. 13 N., R. 12 W., from which casing was being pulled in May, resulted in further drilling that added materially to the northeastern extent of the old Naborton pool. Late in 1916 the center of drilling activity was in the Grand Bayou locality, in sec. 32, T. 13 N., R. 11 W.,

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efforts there being directed toward proving or disproving the theory of a connection between the De Soto and the Crichton fields.

Near the western boundary of De Soto Parish several tests were drilling at the end of the year, near Logansport, favorable attention having been directed to this locality early in 1916 by the discovery of oil in small quantities at a depth of 2,670 feet in a wildcat well drilled by the Citizens' Oil & Gas Co. on the Bland lease in sec. 11, T. 11 N., R. 16 W.

Additional work in the Pelican district in southern De Soto and northern Sabine parishes was without significant consequences.

Red River Parish.—In the early months of 1916 much activity in drilling prevailed in the Crichton district in the southwestern part of T. 13 N., R. 10 W., and in the adjoining part of the township to the west. By March, however, the field had been rather thoroughly defined, its flush production had been exhausted, and subsequent activity was slight. The completion in September as a 2,000-barrel oil well of a wildcat test in sec. 33, T. 13 N., R. 11 W., 2½ miles southwest of the prolific "Gusher Bend" locality, brought about considsiderable activity in what came to be called the Grand Bayou district midway between the Crichton field and the De Soto Parish field, an activity which resulted in the completion of a number of oil wells of fair capacity in the intervening territory in both Red River and De Soto parishes.

In the northern part of Red River Parish wildcat drilling resulted in the completion in May of a gas well having an estimated initial capacity of 30,000,000 cubic feet a day on the A. N. Sample lease, in sec. 3, T. 14 N., R. 11 W.

Bossier Parish.—Persistent efforts, over a period of several years, to find oil and gas in commercial quantities in Bossier Parish were rewarded in 1916 by the discovery of a prolific gas field in the vicinity of Elmgrove, in the southern part of this parish. The discovery well was completed by the Atlas Oil Co. in January on the Elston lease, in sec. 20, T. 16 N., R. 11 W., and was credited with an initial flow of 3,000,000 cubic feet of gas from a sand entered at a depth of about 900 feet.

The completion of No. 2 on this lease in February as a 30,000,000-foot gasser furnished the real incentive for further drilling, which brought about the development of a rich gas field located unfortunately remote from adequate markets. Only one well, the Gulf Refining Co.'s No. 1 Hodges, in sec. 24, T. 16 N., R. 12 W., completed in September, produced oil, subsequent tests in the same locality yielding gas only.

In the northern part of Bossier Parish deep barren tests were completed in 1916 in sec. 25, T. 20 N., R. 14 W., and in sec. 22, T. 22 N., R. 13 W.

Bienville Parish.—After encountering gas in considerable volume in upper sands the deep test of the Arkansas Natural Gas Co., on the east side of Lake Bistineau, in sec. 14, T. 16 N., R. 10 W., was abandoned in August at a total depth of about 3,000 feet. At the end of 1916 other tests in this parish were being drilled on the Shehee lease in sec. 11, and on the State lease in sec. 29, of the same township.

Natchitoches Parish.—Wildcat drilling in the vicinity of Black Lake in the northern part of Natchitoches Parish, though active throughout 1916, failed to result in consequential discoveries of

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either oil or gas. Favorable indications of oil and sufficient gas for drilling purposes were, however, found.

Winn Parish.—At the end of 1916 tests were under way in Winn Parish by the Pardee Oil Co. in sec. 30, T. 11 N., R. 2 W., and by A. J. Yoke and others in sec. 17, T. 10 N., R. 5 W.

Morehouse Parish.—The partial development of a new gas field of importance followed the discovery early in September of gas in fair volume in a wildcat test drilled by the Progressive Oil & Gas Co. in sec. 9, T. 20 N., R. 5 E., and of gas in much greater volume in a subsequent test by the same company in sec. 33 of the adjoining township to the north. The gas was encountered at a depth of about 2,300 feet, and plans were made for piping it to Monroe and Bastrop.

Avoyelles Parish.—A deep test begun by the Black River Oil Co. in September, on the Cole tract, in sec. 30, T. 4 N., R. 4 E., had reached a reported depth of 3,315 feet before the end of 1916.

SALT-DOME DIVISION.

Vinton.—Slight extensions of producing territory both to the north and to the south furnished sufficient new production to increase Vinton's yield of petroleum 33 per cent over the output in 1915 and to make this pool the leading contributor to the petroleum output of the salt-dome division in Louisiana. Of 44 wells drilled during the year at Vinton, 31 were credited with an average yield of 2,035 barrels of oil each the first day of productive life, 1 produced gas, and 12 were failures.

Edgerly.—Operations in the Edgerly pool attained normal proportions in 1916, but resulted in no significant developments. Of 51 wells completed in this pool, 44 were credited with an average yield of 971 barrels of oil each, and the remaining 7 were failures.

Jennings.—Increased drilling in the Jennings pool resulted in a gain of 81,859 barrels, or 19 per cent, in petroleum output in 1916 over 1915. Forty-two wells were completed—28 oil wells and 14 dry holes. New oil wells averaged 185 barrels each the first 24 hours after completion.

Anse la Butte.—One 300-barrel oil well and 3 dry holes were the results of drilling in the old Anse la Butte pool in 1916. Production declined 8,164 barrels, or 39 per cent, compared with 1915.

Welsh.—No oil wells were completed in the Welsh pool in 1916, and production declined 12,132 barrels, or 74 per cent, compared with 1915.

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MARKETED PRODUCTION.

Petroleum marketed in Louisiana, 1907–1916, in barrels.

Year.	Northern Louisiana.				
	Caddo.	De Soto.	Red River.	Sabine.	Total.
1907	50,000				50,000
1908	499,937				499,937
1909	1,028,818				1,028,818
1910	5,090,793				5,090,793
1911	6,995,828				6,995,828
1912	7,177,949				7,177,949
1913	9,781,560				9,781,560
1914	7,572,254	[a] 3,834,593	401,622		11,808,469
1915	6,471,879	1,797,175	6,802,349	10,631	15,082,034
1916	5,463,682	1,657,216	4,691,323	9,421	11,821,642

Year.	Coastal Louisiana.						Total.
	Jennings.	Welsh.	Anse la Butte.	Vinton.	Edgerly.	Total.	
1907	4,842,520	47,316	60,385			4,950,221	5,000,221
1908	5,111,577	31,555	145,805			5,288,937	5,788,874
1909	1,966,614	26,169	37,930			2,030,713	3,059,531
1910	1,625,159	54,724	44,018	26,701		1,750,602	6,841,395
1911	1,180,177	27,901	62,411	2,454,103		3,724,592	10,720,420
1912	1,105,711	22,140	25,000	932,639		2,085,490	9,263,439
1913	790,648	31,144	6,612	1,888,864		2,717,268	12,498,828
1914	412,036	18,629	18,623	1,465,302	586,376	2,500,966	14,309,435
1915	434,815	16,451	20,982	1,234,227	1,403,030	3,109,505	18,191,539
1916	516,674	4,319	12,818	1,640,147	1,252,538	3,426,496	15,248,138

[a] Includes Sabine.

Petroleum marketed in Louisiana in 1915 and 1916, in barrels.

1915.

Month.	Northern Louisiana.				
	Caddo.	De Soto.	Red River.	Sabine.	Total.
January	560,925	158,757	95,638	1,049	816,369
February	527,645	170,225	203,651	1,011	902,532
March	563,941	180,083	325,142	221	1,069,387
April	534,933	243,611	389,142	505	1,168,191
May	540,486	344,491	385,106	1,067	1,271,150
June	533,905	98,385	607,769	801	1,240,860
July	524,589	96,151	883,650	1,469	1,505,859
August	649,238	87,182	917,132	319	1,653,871
September	592,904	85,456	911,920	2,043	1,592,323
October	501,846	117,997	725,382	1,144	1,346,369
November	475,829	101,675	690,975	360	1,268,839
December	465,638	113,162	666,842	642	1,246,284
	6,471,879	1,797,175	6,802,349	10,631	15,082,034

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Petroleum marketed in Louisiana in 1915 and 1916, in barrels—Continued.

1915—Continued.

Month.	Coastal Louisiana						Total.
	Anse la Butte.	Edgerly.	Jennings.	Vinton.	Welsh.	Total.	
January	1,179	89,063	37,662	106,063	3,328	237,295	1,053,664
February	1,762	101,017	33,376	133,492	858	270,505	1,173,037
March	2,984	95,226	35,814	138,087	1,640	273,751	1,343,138
April	1,327	124,623	34,293	126,916	858	288,017	1,456,208
May	2,105	97,607	33,328	88,906	1,570	223,516	1,494,666
June	1,492	106,414	35,366	86,395	858	230,525	1,471,385
July	1,938	117,714	32,061	91,937	858	244,508	1,750,367
August	1,026	147,553	37,002	86,989	858	273,428	1,927,299
September	1,418	116,994	36,231	90,071	1,609	246,323	1,838,646
October	1,916	161,688	39,880	85,194	2,294	290,972	1,637,341
November	2,364	128,509	39,839	77,109	858	248,679	1,517,518
December	1,471	116,622	39,963	123,068	862	281,986	1,528,270
	20,982	1,403,030	434,815	1,234,227	16,451	3,109,505	18,191,539

1916.

Month.	Northern Louisiana.				
	Caddo.	De Soto.	Red River.	Sabine.	Total.
January	439,747	108,211	601,705	327	1,149,990
February	414,599	112,335	546,691	709	1,074,334
March	457,947	137,418	539,676	1,290	1,136,331
April	452,376	130,358	483,887	688	1,067,309
May	494,679	176,594	427,327	1,104	1,099,704
June	477,497	183,688	380,154	998	1,042,337
July	482,925	170,587	343,587	717	997,816
August	474,683	144,918	327,265	1,032	947,898
September	447,114	123,630	305,977	331	877,052
October	453,336	129,892	292,160	896	876,284
November	427,111	123,672	224,403	850	776,036
December	441,668	115,913	218,491	479	776,551
	5,463,682	1,657,216	4,601,323	9,421	11,821,642

Month.	Coastal Louisiana.						Total.
	Anse la Butte.	Edgerly.	Jennings.	Vinton.	Welsh.	Total.	
January	1,315	85,893	34,423	95,689	366	217,686	1,367,676
February	2,501	110,058	28,442	163,160	1,823	305,984	1,380,318
March	3,143	108,519	29,425	205,277	658	347,022	1,483,353
April	899	116,602	40,146	170,946	292	328,885	1,396,194
May	899	108,950	48,730	155,164	303	314,046	1,413,750
June	1,055	124,276	48,146	131,987	293	305,757	1,348,094
July	589	113,908	51,732	137,925	.....	304,154	1,301,970
August	896	112,220	52,280	115,146	290	280,832	1,228,730
September	375	75,183	41,589	110,486	.....	227,633	1,104,685
October	433	93,351	46,559	118,326	294	258,963	1,135,247
November	279	100,894	48,815	120,102	.....	270,090	1,046,126
December	434	102,684	46,387	115,939	.....	265,444	1,041,995
	12,818	1,252,538	516,674	1,640,147	4,319	3,426,496	15,248,138

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Petroleum marketed in Louisiana in 1915 and 1916, with increase or decrease.

District.	1915			1916			Increase or decrease.	
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Barrels.	Per cent.
Northern Louisiana:								
Caddo	6,471,879	$4,597,558	$0.710	5,463,682	$6,123,053	$1.121	−1,008,197	−15.58
De Soto	1,797,175	1,108,875	.617	1,657,216	1,999,217	1.206	− 139,959	− 7.79
Red River	6,802,349	3,652,124	.537	4,691,323	4,044,865	.862	−2,111,026	−31.03
Sabine	10,631	6,786	.638	9,421	11,127	1.181	− 1,210	−11.38
	15,082,034	9,365,343	.621	11,821,642	12,178,262	1.030	−3,260,392	−21.62
Coastal Louisiana:								
Jennings	434,815	211,114	.486	516,674	389,453	.754	+ 81,859	+18.83
Welsh	16,451	13,815	.840	4,319	4,319	1.000	− 12,132	−73.75
Anse la Butte	20,982	16,388	.781	12,818	12,818	1.000	− 8,164	−38.91
Vinton	1,234,227	564,509	.459	1,640,147	1,209,110	.737	+ 405,920	+32.89
Edgerly	1,403,030	633,484	.452	1,252,538	875,812	.699	− 150,492	−10.73
	3,109,505	1,439,310	.463	3,426,496	2,491,512	.727	+ 316,991	+10.19
Total Louisiana	18,191,539	10,804,653	.594	15,248,138	14,669,774	.962	−2,943,401	−16.18

Petroleum marketed, value, and average price per barrel in the Caddo field, 1906–1916.

Year.	Caddo, La.			Marion County, Tex.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity. (barrels).	Value.	Average price per barrel.
1906	3,358	$2,183	$0.650	.....	.....	.....	3,358	$2,183	$0.650
1907	50,000	38,863	.777	.....	.....	.....	50,000	38,863	.777
1908	499,937	214,048	.428	.....	.....	.....	499,937	214,048	.428
1909	1,028,818	549,081	.533	.....	.....	.....	1,028,818	549,081	.533
1910	5,090,793	2,292,349	.451	251,717	$102,842	$0.409	5,342,510	2,395,191	.448
1911	6,995,828	3,653,725	.522	677,689	365,067	.539	7,673,517	4,018,792	.524
1912	7,177,949	5,419,541	.755	362,870	290,974	.802	7,540,819	5,710,515	.757
1913	9,781,560	9,812,342	1.003	262,392	201,965	.998	10,043,952	10,074,307	1.003
1914	7,572,254	7,177,535	.948	180,584	175,922	.974	7,752,838	7,353,457	.948
1915	6,471,879	4,597,558	.710	123,464	88,079	.713	6,595,343	4,685,637	.710
1916	5,463,682	6,123,053	1.121	64,971	80,305	1.236	5,528,653	6,203,358	1.122
	50,136,058	39,880,278	.795	1,923,687	1,365,154	.709	52,059,745	41,245,432	.792

SUMMARY OF WELLS DRILLED.

The statistics of field operations presented in the following tables are compiled from trade-journal sources and differ somewhat from those on page 709, obtained from reports received directly from the oil producers.

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Wells completed in Louisiana, 1912–1916.

District.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Northern Louisiana:															
Avoyelles	....	....	....	....	....	....	....	....	....	1	....	....	....	....	1
Bossier	....	....	....	....	2	....	....	3	5	22	....	....	3	5	39
Caddo	239	356	208	67	194	62	92	54	32	54	353	[b]518	291	107	269
Claiborne	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2
De Soto	....	....	77	23	20	....	....	24	17	25	....	(c)	123	49	64
Natchitoches	....	....	....	....	....	....	....	....	....	4	....	....	....	....	4
Rapides	....	....	....	....	....	....	1	1	....	1	....	1	3	....	1
Red River	....	....	14	257	99	....	....	7	30	33	....	....	21	296	139
Sabine	....	....	3	2	....	....	....	3	5	....	....	(c)	7	7	....
Tensas	....	....	....	....	....	....	....	....	....	1	....	....	....	....	1
	239	356	302	349	324	62	93	94	89	141	353	519	448	464	520
Coastal Louisiana:															
Anse la Butte	3	5	3	1	1	4	1	....	3	3	7	6	3	4	4
Calcasieu	....	4	....	....	....	....	1	2	2	....	....	5	2	2	....
Cameron	....	....	....	....	....	....	2	1	....	3	....	2	1	....	3
Edgerly	....	....	30	35	44	....	....	16	2	7	....	....	46	38	51
Evangeline	....	....	....	....	....	....	1	....	....	....	....	1	....	....	....
Jefferson Davis	....	....	....	....	....	....	....	....	....	1	....	....	....	....	1
Jennings	24	19	12	16	28	9	9	9	6	14	33	28	21	22	42
Pine Prairie	1	2	....	....	....	5	4	....	....	....	6	6	....	....	....
Terrebonne	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....
Vinton	31	45	22	19	31	7	34	12	11	12	38	79	35	31	44
Welsh	....	6	5	2	....	....	4	5	2	1	....	10	10	4	1
	59	81	72	73	104	25	56	45	26	41	84	138	118	101	146
Total Louisiana	298	437	374	422	428	87	149	139	115	182	437	657	566	565	666

[a] Including gas well. [b] Including De Soto and Sabine parishes. [c] Included in Caddo.

Oil wells and dry holes drilled in Louisiana in 1916.

District.	January.		February.		March.		April.		May.		June.		July.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Northern Louisiana:														
Avoyelles	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Bossier	....	....	....	....	....	2	....	2	....	....	....	....	....	2
Caddo	7	3	11	6	16	4	15	5	26	4	22	2	21	4
De Soto	....	2	4	2	5	2	....	1	3	2	2	1	6	2
Natchitoches	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Rapides	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Red River	17	5	18	3	19	4	12	....	11	1	8	....	3	2
Tensas	....	1	....	....	....	....	....	....	....	....	....	....	....	....
	24	11	33	11	40	12	27	8	40	7	32	3	30	10
Coastal Louisiana:														
Anse la Butte	1	....	....	....	....	....	....	....	....	....	....	2	....	....
Cameron	....	....	....	....	....	....	....	....	....	....	....	....	....	1
Edgerly	1	1	3	1	3	1	3	1	2	....	3	1	3	....
Jefferson Davis	....	1	....	....	....	....	....	....	....	....	....	....	....	....
Jennings	1	1	1	1	1	....	3	....	2	....	4	3	4	2
Vinton	3	1	5	....	4	1	2	1	....	2	3	3	2	1
Welsh	....	1	....	....	....	....	....	....	....	....	....	....	....	....
	6	5	9	2	8	2	8	2	4	2	10	9	9	4
Total Louisiana	30	16	42	13	48	14	35	10	44	9	42	12	39	14

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Oil wells and dry holes drilled in Louisiana in 1916—Continued.

District.	August.		September.		October.		November.		December.		Total.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Northern Louisiana:												
Avoyelles	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	1
Bossier	.....	2	1	9	1	3	.....	.....	.....	2	2	22
Caddo	19	6	28	4	13	8	8	4	8	4	194	54
De Soto	5	4	.....	.....	2	3	2	2	.....	4	29	25
Natchitoches	.....	2	.....	1	.....	1	.....	.....	.....	.....	.....	4
Rapides	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	1
Red River	3	5	2	4	1	6	4	1	1	2	99	33
Tensas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
	27	19	31	18	17	22	14	7	9	13	324	141
Coastal Louisiana:												
Anse la Butte	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	1	3
Cameron	.....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	3
Edgerly	7	.....	5	.....	2	2	7	.....	5	.....	44	7
Jefferson Davis	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Jennings	2	2	2	1	2	2	2	.....	4	2	28	14
Vinton	2	1	2	1	4	.....	1	.....	3	1	31	12
Welsh	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
	11	5	9	3	8	4	10	.....	12	3	104	41
Total Louisiana	38	24	40	21	25	26	24	7	21	16	428	182

Wells completed in Louisiana, 1912–1916.

Month.	Oil.					Dry.					Total completed.[a]				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
January	12	36	28	18	30	2	12	5	5	16	17	53	38	24	53
February	19	25	33	25	42	8	10	10	12	13	31	44	48	41	65
March	19	28	44	23	48	1	9	12	6	14	22	44	60	30	66
April	14	45	35	39	35	6	16	12	12	10	21	65	50	54	47
May	30	39	49	42	44	4	5	18	2	9	34	49	74	45	63
June	28	23	50	49	42	11	17	17	16	12	46	44	69	67	59
July	25	51	33	48	39	7	15	10	8	14	37	73	48	57	55
August	28	37	29	43	38	6	10	12	13	24	43	54	47	59	65
September	34	43	20	40	40	15	12	8	8	21	57	58	36	48	67
October	27	34	12	32	25	15	11	12	10	26	44	51	29	42	53
November	37	34	19	30	24	8	14	11	13	7	51	51	33	46	34
December	25	42	22	33	21	4	18	12	10	16	34	71	36	52	39
	298	437	374	422	428	87	149	139	115	182	437	657	566	565	666

[a] Including gas wells.

Initial daily production of new wells completed in Louisiana in 1916, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Northern Louisiana:													
Bossier	.....	.....	.....	.....	.....	.....	.....	.....	75	100	.....	.....	175
Caddo	400	460	2,130	1,385	2,081	1,840	3,400	890	2,345	500	410	380	16,221
De Soto	.....	1,775	4,560	.....	2,290	1,975	1,390	1,190	.....	125	120	.....	13,425
Red River	7,315	5,625	4,975	1,580	1,080	685	215	215	1,785	40	1,495	40	25,050
	7,715	7,860	11,665	2,965	5,451	4,500	5,005	2,295	4,205	765	2,025	420	54,871
Coastal Louisiana:													
Anse la Butte	300	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	300
Edgerly	25	2,650	5,500	4,950	3,200	3,700	2,050	3,950	3,690	310	4,350	7,850	42,725
Jennings	40	50	100	725	60	1,615	850	450	250	175	400	480	5,195
Vinton	27,500	9,450	14,700	400	.....	880	2,000	450	3,100	1,760	50	2,800	63,090
	27,865	12,150	20,300	6,075	3,260	6,195	4,900	4,850	7,040	2,245	5,300	11,130	111,310
Total Louisiana	35,580	20,010	31,965	9,040	8,711	10,695	9,905	7,145	11,245	3,010	7,325	11,550	166,181

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Total and average initial daily production of new wells in Louisiana, 1912–1916, by districts, in barrels.

District.	Total initial production.					Average per well.				
	1912	1913	1914	1915	1916	1912	1913	1914	1915	1916
Northern Louisiana:										
Bossier					175					87.5
Caddo	84,098	a151,955	19,241	14,320	16,221	351.9	426.8	92.5	213.7	83.6
De Soto			70,612	8,190	13,425			917.0	356.1	462.9
Red River			12,185	175,551	25,050			870.4	683.1	253.0
Sabine			155	55				51.7	27.5	
	84,098	151,955	102,193	198,116	54,871	351.9	426.8	338.4	567.7	169.4
Coastal Louisiana:										
Anse la Butte	590	2,362	340	50	300	196.7	472.4	113.3	50.0	300.0
Calcasieu		1,780					445.0			
Edgerly			38,785	32,960	42,725			1,292.8	941.7	971.0
Jennings	5,905	4,813	592	3,390	5,195	246.0	253.3	49.3	211.9	185.5
Pine Prairie	1,050	80				1,050.0	40.0			
Vinton	17,975	46,605	43,070	8,715	63,090	579.8	1,035.7	1,957.7	458.7	2,095.2
Welsh		100	127	70			16.7	25.4	35.0	
	25,520	55,740	82,914	45,185	111,310	432.5	688.1	1,151.6	619.0	1,070.3
Total Louisiana	109,618	207,695	185,107	243,301	166,181	367.8	475.3	494.9	576.5	388.3

a Including De Soto and Sabine parishes.

Total initial daily production of new wells in Louisiana, 1912–1916, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1912	10,855	5,257	10,070	18,300	11,447	3,583	4,931	3,391	17,605	5,600	13,631	4,948	109,618	9,135
1913	21,064	12,410	27,220	28,860	26,986	13,966	15,675	22,626	6,580	11,163	3,447	17,698	207,695	17,308
1914	8,570	10,155	36,305	22,493	17,057	26,212	17,742	10,785	17,367	4,805	6,390	7,226	185,107	15,426
1915	4,890	11,985	23,535	23,365	21,355	20,975	29,341	26,230	34,270	17,705	14,400	15,250	243,301	20,275
1916	35,580	20,010	31,965	9,040	8,711	10,695	9,905	7,145	11,245	3,010	7,325	11,550	166,181	13,848

ROCKY MOUNTAIN OIL FIELD.

GENERAL STATEMENT.

The Rocky Mountain field embraces all areas of production of petroleum in Colorado, Wyoming, and Montana, as well as a number of areas of prospective production in Utah and New Mexico. Petroleum in this field is obtained from strata of Carboniferous and Cretaceous age, the oil occurring generally in sandstone layers, though found occasionally in limestone and rarely in fracture zones in shale. Anticlinal and dome structures are the most favored places of accumulation of oil, though areas of commercial production have been found in this field on monoclinal and terrace structures. The oils from older strata range in gravity from 18° to 24° Baumé, are of asphalt base, and are utilized chiefly for fuel; those from the Cretaceous rocks range between 32° and 48° Baumé, are of paraffin base, and are in wide demand for refining.

This field has been a contributor to the petroleum production of the United States since oil was first found in Colorado in 1887, but has attained importance only with the successful development of the Wyoming fields in the last five years.

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MARKETED PRODUCTION.

Petroleum marketed in the Rocky Mountain field in 1915 and 1916, in barrels.

Month.	1915			1916			
	Colorado.	Wyoming.	Total.	Colorado.	Wyoming.	Montana.	Total.
January	18,262	338,089	356,351	19,406	347,145	.....	366,551
February	15,758	254,930	270,688	13,552	235,344	.....	248,896
March	16,317	354,381	370,698	13,510	492,720	.....	506,230
April	18,024	196,834	214,858	19,507	471,944	.....	491,451
May	15,027	248,088	263,115	23,556	503,426	.....	526,982
June	14,022	395,364	409,386	17,228	530,222	323	547,773
July	17,322	394,182	411,504	14,126	574,826	1,840	590,792
August	14,509	437,165	451,764	10,219	637,708	9,376	657,303
September	15,907	372,956	388,863	9,967	639,182	2,854	652,003
October	16,696	452,994	469,690	11,022	617,220	10,910	639,152
November	21,056	388,540	409,596	12,545	594,066	10,924	617,535
December	25,465	412,022	437,487	32,397	630,334	8,690	671,421
	208,475	4,245,525	4,454,000	197,235	6,234,137	44,917	6,476,289

The following table, which has not appeared in preceding reports of this series, shows the complete statistical history of petroleum development in the Rocky Mountain field, and includes related data formerly presented in separate tables for each State embraced in this field:

Petroleum marketed in the Rocky Mountain field, 1887–1916.

Year.	Quantity (barrels).	Percentage of total production.	Increase or decrease.		Value.	Yearly average price per barrel.
			Barrels.	Per cent.		
1887	76,295	0.27	.....	.....	$76,295	$1.000
1888	297,612	1.07	+ 221,317	+ 29.01	267,851	.900
1889	316,476	.90	+ 18,864	+ 6.34	280,240	.885
1890	368,842	.80	+ 52,366	+ 16.54	309,827	.840
1891	665,482	1.22	+ 296,640	+ 80.42	559,005	.840
1892	824,000	1.63	+ 158,518	+ 23.82	692,160	.840
1893	594,390	1.22	− 229,610	− 27.86	497,581	.838
1894	518,115	1.05	− 76,275	− 12.83	319,572	.617
1895	441,687	.83	− 76,428	− 14.75	363,650	.823
1896	364,328	.59	− 77,359	− 17.51	342,001	.939
1897	388,584	.64	+ 24,256	+ 6.66	361,322	.930
1898	449,858	.80	+ 61,274	+ 15.77	405,772	.902
1899	395,838	.69	− 54,020	− 12.01	443,090	1.119
1900	322,835	.50	− 73,003	− 18.44	361,584	1.120
1901	465,920	.66	+ 143,085	+ 44.32	498,831	1.071
1902	403,154	.45	− 62,766	− 13.47	528,454	1.311
1903	492,885	.48	+ 89,731	+ 22.26	494,443	1.003
1904	513,305	.43	+ 20,420	+ 4.14	658,829	1.284
1905	384,692	.28	− 128,613	− 25.06	389,151	1.012
1906	334,582	.26	− 50,110	− 13.03	311,675	.932
1907	341,190	.205	+ 6,608	+ 1.98	294,696	.863
1908	397,428	.22	+ 56,238	+ 16.48	374,323	.942
1909	330,917	.18	− 66,511	− 16.74	352,618	1.066
1910	355,224	.17	+ 24,307	+ 7.35	336,938	.949
1911	413,621	.185	+ 58,397	+ 16.44	352,141	.851
1912	1,778,358	.80	+1,364,737	+329.95	998,131	.561
1913	2,595,321	1.04	+ 816,963	+ 45.94	1,362,011	.525
1914	3,783,148	1.43	+1,187,827	+ 45.77	1,880,066	.497
1915	4,454,000	1.585	+ 670,852	+ 17.73	2,400,503	.539
1916	6,476,289	2.153	+2,022,289	+ 45.40	5,905,238	.912
	29,544,376	.754	.....	.....	22,417,958	.759

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Petroleum marketed, value, and average price per barrel in the Rocky Mountain field, 1907–1916, by States.

Year.	Colorado.			Wyoming.			Montana.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1907	331,851	$272,813	$0.822	a 9,339	$21,883	$2.343	.....	.....	.....	341,190	$294,696	$0.863
1908	379,653	346,403	.913	a 17,775	27,920	1.570	.....	.....	.....	397,428	374,323	.942
1909	310,861	318,162	1.023	a 20,056	34,456	1.718	.....	.....	.....	330,917	352,618	1.066
1910	239,794	243,402	1.015	a115,430	93,536	.810	.....	.....	.....	355,224	336,938	.949
1911	226,926	228,104	1.005	a186,695	124,037	.664	.....	.....	.....	413,621	352,141	.851
1912	206,052	199,661	.973	1,572,306	798,470	.507	.....	.....	.....	1,778,358	998,131	.561
1913	188,799	174,779	.926	2,406,522	1,187,232	.493	.....	.....	.....	2,595,321	1,362,011	.525
1914	222,773	200,894	.902	3,560,375	1,679,192	.472	.....	.....	.....	3,783,148	1,880,086	.497
1915	208,475	183,485	.880	4,245,525	2,217,018	.522	.....	.....	.....	4,454,000	2,400,503	.539
1916	197,235	217,139	1.100	6,234,137	5,644,080	.905	44,917	$44,019	$0.98	6,476,289	5,905,238	.912

a Includes Utah.

Petroleum marketed in the Rocky Mountain field, 1914–1916, in barrels.

Month.	1914	1915	1916
January	216,558	356,351	366,551
February	179,011	270,688	248,896
March	246,825	370,698	506,230
April	318,235	214,858	491,451
May	394,112	263,115	526,982
June	239,295	409,386	547,773
July	307,244	411,504	550,792
August	398,804	451,764	657,303
September	406,472	388,863	652,003
October	394,274	469,690	639,152
November	362,773	409,596	617,535
December	319,545	437,487	671,621
	3,783,148	4,454,000	6,476,289

Average daily production of petroleum in the Rocky Mountain field, 1914–1916, in barrels.

Month.	1914	1915	1916
January	6,986	11,495	11,824
February	6,393	9,664	8,889
March	7,962	11,958	16,330
April	10,608	7,162	16,382
May	12,713	8,487	16,999
June	7,980	13,646	18,259
July	9,911	13,274	17,767
August	12,864	14,573	21,203
September	13,549	12,962	21,733
October	12,719	15,151	20,618
November	12,092	13,653	20,585
December	10,308	14,112	21,665
Average	10,365	12,203	17,743

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PIPE-LINE RUNS, DELIVERIES, AND STOCKS.

Pipe-line runs and deliveries to trade of petroleum from the Rocky Mountain field and stocks at end of each month in 1915 and 1916, in barrels.

Month.	1915			1916		
	Runs.	Deliveries.	Stocks.	Runs.	Deliveries.	Stocks.
Dec. 31, 1914			170,292			
January	356,351	56,350	470,293	366,551	321,709	470,026
February	270,688	264,917	476,064	248,896	346,578	372,344
March	370,698	388,648	458,114	506,230	435,196	443,378
April	214,858	95,131	577,841	491,451	478,221	456,608
May	263,115	411,509	429,447	526,982	527,478	456,112
June	409,386	261,357	577,476	547,773	519,733	484,152
July	411,504	422,245	566,735	550,792	472,872	562,072
August	451,764	590,609	427,890	657,303	527,492	691,883
September	388,963	514,252	302,501	652,003	596,444	747,442
October	469,690	488,571	283,620	639,152	585,188	801,406
November	409,596	330,975	362,241	617,535	637,092	781,849
December	437,487	374,544	425,184	671,621	708,289	745,181
	4,454,000	4,199,108		6,476,289	6,156,292	

PRICES.

As reported by the Illinois Pipe Line Co., the principal transporter of petroleum from the Wyoming fields, the market for Wyoming oil followed in 1916 the general course of the market for eastern and Mid-Continent grades. Opening the year at 75 cents a barrel, Wyoming oil advanced to $1 on March 16 and to $1.10 on May 19. On August 4 it declined to $1 a barrel and on August 25 to 90 cents. On December 2, however, it again advanced to $1 a barrel, and on December 13 to $1.10, the price at which the market closed on December 31.

COLORADO.

GENERAL STATEMENT.

The contribution of Colorado to the petroleum supply of the United States, which has never been large, was less by 11,240 barrels, or 5 per cent, than the output in 1915. The quantity marketed was 197,235 barrels, of which 97 per cent came from the Florence district, in Fremont County, and the remaining 3 per cent from the Boulder field, in Boulder County. The average price received at the wells for this oil was $1.10 a barrel, and the total market value of the output was $217,139, of which 95 per cent is credited to the Florence district and 5 per cent to Boulder. The average market price in 1916 was 22 cents higher than in 1915, and the total value of the output was 18 per cent greater. The output of the Florence district was 5 per cent less and that of the Boulder district 10 per cent less than in 1915.

No petroleum was marketed in 1916 from the Rangely district in Rio Blanco County, or from the De Beque district, in Mesa County. In the latter locality much interest was taken in the possibilities of the recovery of petroleum from the petroliferous shales of the Green River formation (Eocene) and a great number of claims were filed on shale land in Garfield and Mesa counties. Plans were completed

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by the Oil Shale Mining Co. for the erection of a distillation plant on Dry Fork of Roan Creek, about 10 miles northwest of De Beque. The recovery of petroleum by the distillation of shale promises to develop into an important industry in western Colorado in the course of the next four or five years.

That Garfield County will be listed among the contributors to the petroleum output of Colorado in 1917 was assured in 1916 by the completion of plans by the Urado Oil Co. for the erection of a small refinery near its oil property in the extreme western part of the county adjacent to the Utah State boundary.

In other parts of Colorado unsuccessful wildcat tests were completed in 1916 near Wellington, Larimer County, and near Alamosa, Alamosa County. At the end of the year interest in wildcat drilling was centered in wells in Wildhorse Park, Pueblo County, about 20 miles east of the Florence district.

MARKETED PRODUCTION.

Petroleum marketed in Colorado in 1915 and 1916, by districts, in barrels.

Month.	1915				1916		
	Boulder.	Florence.	Other.	Total.	Boulder.	Florence.	Total.
January	901	17,381	.....	18,282	368	19,038	19,406
February	545	15,213	.....	15,758	635	12,917	13,552
March	579	15,738	.....	16,317	377	13,133	13,510
April	638	17,386	.....	18,024	380	19,127	19,507
May	478	14,549	.....	15,027	368	23,188	23,556
June	442	13,580	.....	14,022	764	16,464	17,228
July	596	16,726	.....	17,322	374	13,752	14,126
August	501	14,098	.....	14,599	595	9,624	10,219
September	210	15,697	.....	15,907	500	9,467	9,967
October	571	16,125	.....	16,696	585	10,437	11,022
November	454	20,603	.....	21,056	434	12,111	12,545
December	461	24,974	.....	25,435	369	32,228	32,597
	6,376	202,069	30	208,475	5,749	191,486	197,235
Decrease in 1916:							
Barrels	.....	.....	.....	.....	627	10,583	11,240
Per cent	.....	.....	.....	.....	9.83	5.24	5.39

Petroleum marketed, value, and average price per barrel in Colorado, 1907–1916, by districts.

Year.	Boulder.			Florence.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1907	68,353	$75,188	$1.100	263,498	$197,625	$0.750	331,851	$272,813	$0.822
1908	84,174	124,794	1.482	295,479	221,609	.750	379,653	346,403	.913
1909	85,709	129,812	1.514	225,062	187,900	.834	[a] 310,861	318,162	1.023
1910	42,186	63,420	1.503	193,482	174,332	.901	[b] 239,794	243,402	1.015
1911	37,973	50,393	1.327	187,341	175,763	.938	[b] 226,926	228,104	1.005
1912	15,304	19,130	1.250	190,498	180,281	.946	[c] 206,052	199,661	.973
1913	11,796	15,366	1.303	176,693	159,103	.900	[c] 188,799	174,779	.926
1914	6,515	9,117	1.399	215,548	191,067	.886	[d] 222,773	206,894	.902
1915	6,376	9,679	1.518	202,069	173,506	.859	[a] 208,475	183,485	.880
1916	5,749	9,902	1.722	191,486	207,287	1.082	197,235	217,189	1.100

[a] Includes a small production in Garfield County.
[b] Includes production in Garfield and Rio Blanco counties.
[c] Includes production in Rio Blanco County.
[d] Includes production in Mesa and Rio Blanco counties.

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FIELD REPORT.

Field report for oil industry in Colorado in 1915 and 1916.

County.	Wells.									Acreage.					
	1915				1916					1915			1916		
	Productive Jan. 1.	Completed. Oil.	Completed. Dry.	Abandoned.	Productive Dec. 31.	Completed. Oil.	Completed. Dry.	Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.	Fee.	Lease.	Total.
Adams			1											2,920	2,920
Boulder	14				14	1	1	1	14	2,511	215	2,726	2,511	98	2,609
Crowley			1							1,000	1,000	2,000			
Fremont	56	2	4	3	55	1	3		56	8,330	17,480	25,810	6,846	17,320	24,166
Garfield	1				1		1		1	320		320	1,400		1,400
Larimer							1								
Mesa	1			1						300	397	697		300	300
Rio Blanco	23	1		1	23	1		10	14	4,640		4,640	4,800	800	5,600
	95	3	6	5	93	3	6	11	85	17,701	19,092	36,793	15,557	21,438	36,995

WYOMING.

GENERAL STATEMENT.

The steady increase in production of petroleum in Wyoming since 1912 has been attended with the development of such conclusive evidence of the inherent richness of its oil sands that this State has come to be recognized as the dominant factor in the situation with respect to high-grade petroleum in western North America. Its output of crude oil in 1916 confirms the basis of this opinion.

A marketed output of 6,234,137 barrels of petroleum in that year constitutes a new record in Wyoming, which is greater by 1,988,612 barrels, or 47 per cent, than the former record established in 1915. The fact that the greater part of this yield consisted of high-grade refining oil capable of furnishing 15 to 25 per cent of gasoline by modern refining methods indicates for the local industry a position of economic importance not suggested by the statistics alone.

The average price received at the wells for the petroleum marketed in Wyoming in 1916 was 90.5 cents a barrel, and the total market value of the output was $5,644,080, a gain of 38 cents in average unit price and of $3,427,062, or 154 per cent, in total market value over 1915.

Aside from the general increase in crude-oil production, which was in direct response to increased refining facilities provided by enlargements of plant capacity by the Midwest Refining Co., at Casper, and the installation of a new plant by the Greybull Refining Co., at Greybull, developments in the petroleum industry of Wyoming in 1916 included a wildcat campaign that resulted in the opening of new areas of production of much potential importance.

DEVELOPMENT.

Natrona County.—The Salt Creek and Shannon districts in Natrona County furnished, as in recent years, the greater part of the oil marketed in Wyoming in 1916, their combined yield amounting to 3,933,403 barrels. Although this output is slightly less than in 1915, it

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is not an indication that the capacity of the field is declining, but is rather an indication that the interests which control the greater part of it are wisely conserving its vast resources for future needs and are supplying the current needs of their refineries with oil from other fields less capable of maintenance as a natural reserve. A moderate amount of work was, however, done in this district, mostly in the shale area to the west of the Salt Creek uplift, which furnished a number of wells of fair capacity. The most significant development of the year was the discovery in August, in a well drilled by the New York Oil Co. in the northern part of the main field, of a prolific "pay-sand," locally called the "Lower Wall Creek sand," at a depth of about 1,000 feet below the principal source of former production—the Wall Creek sand. Although this discovery adds nothing to the surface area of the field, it adds enormously to its potentialities of oil production.

Converse County.—The principal feature of the petroleum industry in Wyoming in 1916 was the discovery of the Big Muddy field in western Converse County, about 15 miles due east of Casper. The first successful well in this field, located in sec. 3, T. 33 N., R. 76 W., of the sixth principal meridian, was drilled by the Merrit Oil & Gas Co. It was brought in as a 20-barrel well on June 13, and derived its production from the Shannon sand, reached at a depth of 947 feet A well in sec. 10, of the same township, completed in November, demonstrated the presence and productivity of oil of the deeper Wall Creek sand and assured a speedy and successful development of the new district.

Before the end of 1916 a number of successful wells had been completed in the Shannon sand, and several others had been started in quest of the more productive but deeper Wall Creek "pay." The oil found in this field is similar to that obtained in the Salt Creek field, 40 miles to the north. During the closing months of the year the product of this field was marketed at the Casper refineries, to which it was shipped by rail. The field is situated on the crest and flanks of a well-defined anticline described and recommended as a prospective oil field by Barnett [1] in 1914. Sufficient drilling had not been done to the end of 1916 to indicate the limits of the productive area in any direction.

Fremont County.—Petroleum production in Fremont County increased 126 per cent in 1916 compared with 1915 as a consequence of the success that attended the drilling of additional wells by the Hudson Oil Co. and others in the heavy-oil district north of the Popo Agie, near Lander.

In the Pilot Butte district, about 30 miles northwest of Riverton, a number of additional tests were drilled to the shallow sands and capped to await the provision of facilities for marketing their output. Tests were started to determine the presence or absence of productive sands at depth. The enactment by Congress of legislation providing for the leasing of lands in this field, which lies within the boundaries of the Wind River Indian Reservation, resulted in the filing with the Department of the Interior of a great number of appli-

[1] Barnett, V. H., Possibilities of oil in the Big Muddy dome, Converse and Natrona counties, Wyo.: U. S. Geol. Survey Bull. 581, pp. 105–117, 1915.

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cations for leases in the Pilot Butte and Maverick Springs districts, but to the end of 1916 no leases had been granted.

Sweetwater County.—The discovery in May of small quantities of oil at shallow depths in wells drilled on Lost Soldier Flats, in T. 26 N., R. 90 W., in the northeast corner of Sweetwater County, 40 miles north of Rawlins, inspired additional drilling which to the end of 1916 had failed to demonstrate the existence of an oil field of potential importance in this locality.

Uinta County.—Regular shipments of crude oil were made during 1916 from the Spring Valley field, near Evanston, to the plant of the Utah Refining Co., at Salt Lake City. Interest was revived in the potentialities of this old district and plans were made for the drilling of new tests in the Labarge and Fossil localities.

BIG HORN BASIN.

Hot Springs County.—The output of petroleum from the Grass Creek field was more than 1,200 per cent greater than in 1915, as a consequence of the ample marketing facilities that were available throughout 1916 and of the success that attended the aggressive drilling campaign in this district. Of 68 producing wells in the Grass Creek field at the end of December, 31 were brought in during 1916. Drilling was restricted mainly to territory of proved worth, and production increased steadily from an average of 860 barrels a day in January to 5,100 barrels a day in December.

Park County.—No developments of consequence took place in the Buffalo, Little Buffalo, or Oregon Basin districts, in the southern part of Park County, in 1916. A gas well having an initial capacity estimated at 3,000,000 cubic feet a day was completed in September on the rim of Oregon Basin, and one failure was charged to Buffalo Basin.

Farther north, in Park County, a few new wells were drilled in the territory adjacent to Cody, gas being found south of Big Horn River and both gas and oil being found north of it in this locality.

In the Elk Basin district, along the Montana State boundary, 25 new oil wells were completed, development in this field being stimulated by the completion in May by the Illinois Pipe Line Co. of a 6-inch line from the field to Frannie, on the Billings division of the Chicago, Burlington & Quincy Railroad. From Frannie the product of this field was shipped by rail to the refineries at Greybull, Cowley, and Casper, Wyo., and to the Regina plant of the Imperial Oil Co., in Ontario, Canada.

Big Horn County.—The subsidence of the town-lot development at Greybull and the failure of outside tests to find material extensions of the proved pools in the Greybull-Basin district resulted in a slight decline in output of petroleum, compared with that of 1915. In the Byron district developments were likewise featureless. In wildcat territory the most important completion during the year in Big Horn County was that of a gas well with an initial capacity of 7,000,000 cubic feet brought in early in June by the Lamb Drilling Co., in sec. 27, T. 57 N., R. 98 W. sixth principal meridian, on a structure about 10 miles west of Frannie, known as the Mantau dome.

Renewed activity in the old Bonanza field in the southern part of the county failed to result in discoveries of consequence.

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MARKETED PRODUCTION.

Petroleum marketed in Wyoming in 1915 and 1916, by counties, in barrels.

Month.	Big Horn.	Fremont.	Natrona.	Hot Springs.	Other.[a]	Total.
1915.						
January	6,171	1,971	329,363	.....	564	338,069
February	3,234	2,547	248,608	.....	541	254,930
March	4,096	2,547	347,147	.....	591	354,381
April	3,077	2,955	190,218	.....	584	196,834
May	15,353	2,837	229,206	.....	692	248,088
June	36,910	2,738	355,097	.....	619	395,364
July	41,124	2,698	329,954	19,820	586	394,182
August	6,475	2,792	425,723	1,556	619	437,165
September	5,689	2,788	359,849	4,056	574	372,956
October	6,574	2,691	426,703	16,434	592	452,994
November	8,361	548	351,135	27,944	552	388,540
December	3,914	548	378,125	28,913	522	412,022
	140,978	27,660	3,971,128	98,723	7,036	4,245,525
1916.						
January	11,900	1,368	307,023	26,606	248	347,145
February	8,608	1,437	186,696	37,949	654	235,344
March	13,864	1,437	421,957	54,622	840	492,720
April	15,789	9,773	368,651	76,891	840	471,944
May	17,332	9,601	368,734	107,125	544	503,426
June	14,488	9,834	356,976	122,242	26,682	530,222
July	14,771	6,211	317,551	133,863	62,430	534,826
August	12,212	5,351	363,841	162,146	94,158	637,708
September	10,412	2,440	311,327	187,274	127,729	639,182
October	8,900	3,475	296,154	173,368	135,323	617,220
November	7,437	6,017	301,527	129,810	149,275	594,066
December	4,141	5,530	332,966	157,911	129,786	630,334
	139,854	62,564	3,933,403	1,369,807	728,509	6,234,137

[a] Converse, Park, and Uinta counties.

Petroleum marketed, value, and average price per barrel in Wyoming, 1914–1916, by districts.

Year.	Big Horn.			Fremont.			Natrona.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1914	98,178	$96,178	$1.00	27,395	$21,362	$0.780	3,421,326	$1,541,494	$0.451
1915	140,978	133,457	.946	27,660	15,051	.544	3,971,128	1,985,564	.500
1916	139,854	150,884	1.079	62,564	87,275	1.395	3,933,403	3,363,364	.855

Year.	Hot Springs.			Other.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1914	.....	.....	.....	[a] 15,477	$20,158	$1.302	3,560,375	$1,679,192	$0.472
1915	98,723	$74,126	$0.751	[b] 7,036	8,820	1.254	4,245,525	2,217,013	.522
1916	1,369,807	1,336,840	.976	[b] 725,509	705,717	.969	6,234,137	5,644,060	.905

[a] Converse, Crook, and Uinta counties. [b] Converse, Park, and Uinta counties.

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FIELD REPORT.

Field report for oil industry in Wyoming in 1915 and 1916.

County.	Wells.									Acreage.					
	1915					1916				1915			1916		
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Completed.		Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.	Fee.	Lease.	Total.
		Oil.	Dry.			Oil.	Dry.								
Big Horn	37	12	3	2	47	11	4	.....	58	687	9,742	10,429	527	8,039	8,566
Converse	9	.....	.....	1	8	13	3	4	17	927	6,480	7,407	927	3,468	4,395
Crook	12	.....	.....	.....	12	.....	.....	.....	12	760	1,360	2,120	760	800	1,560
Fremont	25	4	.....	1	28	9	3	.....	37	.....	5,600	5,600	815	12,610	13,425
Hot Springs	8	30	5	1	37	31	5	.....	68	920	12,840	13,760	40	7,024	7,064
Natrona	136	16	2	1	151	16	3	2	165	1,960	15,712	17,672	6,030	6,012	12,042
Park	2	.....	.....	.....	2	25	.....	.....	27	310	16,797	17,107	320	19,298	19,618
Uinta	36	.....	1	1	35	1	.....	4	32	7,600	11,800	19,400	7,600	1,760	9,360
	265	62	11	7	320	106	18	10	416	13,164	80,331	93,495	17,019	59,011	76,030

MONTANA.

GENERAL STATEMENT.

The appearance of Montana among the oil-producing States in 1916 was made possible by the marketing of 44,917 barrels of petroleum from the north end of the Elk Basin district, in Carbon County, during that year.

Outside this district which had 10 producing wells at the end of 1916, there was no commercial production of oil in this State.

At the end of 1916 tests were drilling on the Dry Creek anticline, north of Red Lodge, at Golden, and at Silesia, in Carbon County; and near Dillon, in Beaverhead County.

Near Glendive, Dawson County, and near Baker, Fallon County, drilling in 1916 resulted only in the development of additional gas supplies, which are not yet utilized commercially.

UTAH.

DEVELOPMENT.

Interest in the development of petroleum in Utah though keen led to but little actual drilling. In the San Juan district, in San Juan County, 1 dry hole was completed and 1 well formerly classed as a producer of oil was abandoned. The 5 other wells in this field capable of producing oil remained closed during the year because of the absence of marketing facilities for their product.

Late in 1916 interest in the possibilities of production of oil in the old Virgin River district, in Washington County, was revived, and plans were made for the drilling of test wells in 1917.

In northern Utah considerable interest was aroused in Tooele County by the drilling of a deep well near Grants, on the Western Pacific Railroad, 30 miles west of Salt Lake City. A large number of oil claims were located in the vicinity of this well, but nothing of interest to the petroleum industry was found.

In Cache County an unsuccessful test was drilled for oil about half a mile east of Mendon.

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With regard to its bearing on the petroleum industry, the most significant development in Utah in 1916, was the formation there of a number of companies for the purpose of developing the vast deposits of oil shale that exist in Uinta, Grand, Duchesne, Carbon, Emery, Wasatch, Sanpete, and Juab counties. Plans were made by one company for the erection of an experimental plant for the distillation of oil shale, at Manti, in Sanpete County, and by another company for the erection of a similar plant near Colton, Utah County.

FIELD REPORT.

Field report for oil industry in Utah in 1915 and 1916.

County.	Wells.								Acreage.					
	1915				1916				1915			1916		
	Productive Jan. 1.	Completed. Oil.	Completed. Dry.	Abandoned.	Productive Dec. 31.	Completed. Oil.	Completed. Dry.	Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.	Fee.	Lease.	Total.
Cache	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	3,500	3,500
Millard	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....
San Juan	5	1	.....	.....	6	.....	1	1	5	16,257	.....	16,257	11,700	.....	11,700
	5	1	.....	.....	6	.....	3	1	5	16,257	.....	16,257	11,700	3,500	15,200

CALIFORNIA OIL FIELD.

GENERAL STATEMENT.

Despite an increase of more than 4,000,000 barrels, or 5 per cent, in its output of petroleum in 1916, California was again forced to accept second place among the States contributing to the oil supply of the country. Its output in 1916, though greater than in 1915, was still 8.8 per cent below the record yield in 1914. The gain in 1916 was general, amounting to 4 per cent in the San Joaquin Valley division and to 8 per cent in the coastal and southern divisions. Of the various subdivisions of the first division the Sunset district and the McKittrick-Belridge district failed to share in the increase. Gain of 6 per cent in the Midway district was more than ample to offset the loss of 16 per cent in the Sunset district as well as the less serious loss of 1 per cent in the McKittrick-Belridge district. Increase of nearly 11 per cent at Coalinga, of 10 per cent at Lost Hills, and of 8 per cent at Kern River was, therefore, net gain as far as this division was concerned.

In the coastal and southern divisions loss in production of 16 per cent in the Salt Lake district and of 3 per cent at Newhall was offset several times over by the gain of 10 per cent in the output of the Fullerton-Coyote district alone, to say nothing of the substantial increase in the other fields of these divisions not already mentioned.

The average price received at the well for all grades of oil produced in California in 1916 was 59 cents a barrel and the total market value of the output was $53,702,733, a gain of 17 cents in average market price and of $17,144,294, or 47 per cent, in total market value, compared with 1915. Increased demand for petroleum and petroleum products of all kinds for export as well as for domestic consumption

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in the Pacific Coast States resulted in a strong market throughout 1916 for all grades of crude oil produced in California. The year opened with a basic price of 43 cents a barrel for heavy oil (oils above 17.9° Baumé commanding a price 1 cent per barrel higher for each successive advance of one full degree in gravity), which became effective on December 28, 1915. Subsequent advances of 5 cents each became effective on February 2, February 16, April 1, July 7, September 20, and November 21, making the basic quotation 73 cents, a net gain of 30 cents during the year, at the end of 1916.

Despite the stimulus of advancing prices current production was inadequate to meet the increasing demand for California oil and large drafts on stocks were necessary. Stocks of crude oil held by pipe-line companies decreased from 44,588,084 barrels on December 31, 1915, to 39,398,351 barrels on December 31, 1916, a loss of 12 per cent, and the stocks held in field tanks and reservoirs by producing companies decreased from 12,396,000 barrels to 6,761,000 barrels, a loss of nearly 46 per cent, in the same period. The total depletion of stocks in California in 1916 was 10,822,700 barrels, or 19 per cent of the total surface reserve of oil in this State at the beginning of the year.

A discrepancy between production and consumption that necessitates the withdrawal in a single year of an average of 30,000 barrels of oil a day from storage to meet current needs, particularly in a State that was estimated last year to contain an underground reserve of oil in excess of 2,345,000,000 barrels, would appear to require explanation. Its basis is believed to lie on the one hand in rapidly increasing consumption of oil, and on the other hand in a number of factors, the more important of which are (1) the diminishing initial capacity of new wells, (2) the scarcity and high cost of casing and labor, (3) litigation between the Federal Government and various claimants to oil land of great value in San Joaquin Valley, and (4) the delay of the Federal Government in providing legislation that will permit the development and testing of thousands of acres of proved and prospective oil land withdrawn by the President from mineral entry under the act of June 22, 1910. Against this combination of adverse influences the effect of increasing prices for crude oil at the wells is slight. Their well-known tendency to stimulate drilling is operative in California only on areas not affected by Federal withdrawals or Federal litigation, and on such areas their potency can guarantee neither the completion of wells of large capacity, nor an ample supply of casing with which to drill the larger number of wells of moderate capacity required to maintain or to increase production. Unless relief is provided the situation of the petroleum industry in California at the end of 1917 will be most serious.

DEVELOPMENT.

As indicated in the field report on page 846, activity in drilling in California in 1916 was more than twice as great as in 1915. The ratio of dry holes to the combined total of oil wells and dry holes was as 2 to 40 in 1916, compared with the approximate ratio of 2 to 29 in 1915.

SAN JOAQUIN VALLEY DIVISION.

Coalinga.—Although a few wells were completed in 1916 in the Eastside field, the greater part of the drilling activity in the Coalinga district was in the shallower Westside field where the deepening of old wells to the second sand was the principal feature of operations

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in the northern part of this area. The acquisition by the Standard Oil Co. of California of the producing property of the Home Oil Co., in the N. ½ sec. 20, T. 19 S., R. 15 E., in the old Oil City was followed by a cleaning out and redrilling of the six productive wells that resulted in a material increase in the output of the light-gravity oil for which this district is noted.

To the north of the Coalinga district the wildcat test on the Domengine lease, in sec. 27, T. 18 S., R. 15 E., referred to in the report of this series for 1915, proved barren and was abandoned at a reported depth of 4,000 feet.

In the Devils Den district, south of the Coalinga field, interest was centered in the drilling of a deep test by the Marathon Oil Co., in sec. 18, T. 25 S., R. 18 E., near the town site of Satadena.

Lost Hills.—The moderate depth at which production is obtainable and the relatively high grade of the oil found furnished an incentive that made development work especially active in the Lost Hills district in 1916. The trend of development was toward the northwest, along the crest of the Lost Hills anticline, and a large proportion of the new wells completed were in secs. 13 and 24, T. 26 S., R. 20 E.

Two miles southwest of the field a deep test was drilled by the Associated Oil Co. in sec. 17, T. 27 S., R. 21 E. This well had reached a depth reported in excess of 5,000 feet before the end of 1916.

Belridge.—Principal interest in the Belridge district was centered in the new territory 6 miles to the northwest that was proved worthy of development, by the Belridge Oil Co., in 1915. Additional drilling in this locality, which occupies the southeastern part of T. 27 S., R. 20 E., resulted in extensions of the proved territory from sec. 35 to the west and northwest into secs. 34 and 27 and to the east into sec. 36. The depth of the producing sands in this field—about 4,000 feet—renders development work slow.

McKittrick.—In the McKittrick district development work was most active in 1916 along what is known as the McKittrick Front, the territory from 3 to 5 miles north of McKittrick and between the old McKittrick field and the Belridge district. In this area development work was stimulated in 1916 by the completion of wells of moderate capacity at depths of 1,200 to 1,500 feet in sec. 6, T. 30 S., R. 22 E., and sec. 29 of the adjoining township to the north.

Midway.—Activity in development work in the Midway district in 1916 was general, and the gain of 6 per cent in output compared with 1915 can be credited to no particular quarter of the field. One of the most successful completions of the year was that of well No. 60 of the Kern Trading & Oil Co., in sec. 1, T. 32 S., R. 23 E., brought in early in March under perfect control with an initial capacity estimated at 5,000 barrels, of which only about 1,100 barrels was allowed to flow. This well is in the Buena Vista Hills, about 3 miles north of Taft, and is only a short distance from well No. 39, which came in two years earlier as a spectacular gusher with an estimated initial capacity of 30,000 barrels of oil a day.

Sunset.—The year's developments in the Sunset district failed to include any discoveries of especial note. The world-famous well of the Lakeview Oil Co., that came in in 1910 as a 70,000-barrel gusher and for a period of 18 months ran wild, was cleaned out by the Union Oil Co., its present owner, and rejuvenated as a producer capable

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of yielding 30 barrels of oil a day when pumped. Out on Maricopa Flat additional wells of relatively large initial capacity were brought in under perfect control on the holdings of the Union Oil Co. and of the Lakeview No. 2 Oil Co., in sec. 4, T. 11 N., R. 23 W. San Bernardino meridian.

Kern River.—The enhanced value of fuel grades of oil resulted in a decided increase of drilling in the old Kern River field, with excellent results. The greater part of the work was in proved territory and resulted in wells with initial capacities of 15 to 30 barrels each. The most aggressive drilling campaign in this field was conducted by the Associated Oil Co., which completed more than 80 per cent of the new wells in this district in 1916.

No additional oil wells were completed in 1916 in the territory to the west of the main field, though new wells were started in sec. 27, T. 28 S., R. 27 E., near the two producing wells of the Standard Oil Co. of California, drilled in that section in 1914 and 1915.

SOUTHERN DIVISION.

Whittier-Fullerton.—The regularity with which oil wells of relatively large initial capacity were completed on proved leases, particularly in the East Coyote Hills field, was perhaps the most significant feature of development work in the Whittier-Fullerton district in 1916. Only one spectacular well was brought in, No. 7 on the Hole lease of the Union Oil Co., in the East Coyote field. This well blew itself in at a reported depth of 2,980 feet near the end of May and for six hours flowed oil, gas, mud, and water at an estimated rate of 15,000 barrels a day, the flow being stopped by the collapse of the casing at a depth of about 2,400 feet. While being cleaned and deepened this well again broke loose, this time at the unexpected depth of 2,425 feet, and flowed continuously for eight hours on June 30 at an estimated rate of 7,500 barrels a day, when it again sanded. It was subsequently brought in under control, its initial production being about 400 barrels a day from the upper sand. A number of other wells ranging in initial capacity up to 3,000 barrels were completed during 1916 on this lease and on the adjoining Hualde and Anaheim leases of the Amalgamated Oil Co.

At the east end of La Habra valley, about 4 miles southeast of Olinda field, the second unsuccessful test of the Yorba Oil Co., at Yorba Linda, was abandoned in September at a depth of about 3,500 feet.

North of the Brea Canyon field on the north flank of the Puente Hills wildcat tests were started in 1916 on the Fundenburg ranch by the Golden Seal Petroleum Co. and the Copa de Oro Petroleum Co.

Other wildcat tests of interest were started in 1916, west and southwest of this district. These were located as follows: One on the Rancho la Merced midway between Los Angeles and Whittier; one in the Baldwin Hills, a short distance south of Los Angeles; one near Dominguez Junction, 15 miles south of that city; and one near Wilmington, on San Pedro Bay.

Los Angeles-Salt Lake.—A few wells averaging about 20 barrels each in initial capacity were completed in territory already proved in the Salt Lake field, 3 miles west of Los Angeles. In the City field operations were restricted to the pumping of old wells.

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COASTAL DIVISION.

Santa Clara County.—Renewed activity in the Watsonville or Sargent ranch oil field in Santa Clara, consisting of the cleaning and deepening of the old wells and the drilling of one new producer, resulted in a substantial gain in the output of the field.

San Luis Obispo County.—Production of oil in the Edna or Arroyo Grande district, south of San Luis Obispo, remained practically stationary in 1916. Late in the year preparations were made for active drilling in this field and for a thorough test of the surrounding territory.

Santa Barbara County. In the various fields that make up the Santa Maria district there was but little activity in 1916. The completion in April of a well credited with an initial capacity of 500 barrels of 10° Baumé gravity oil by the Casmalia Syndicate Co. on the Juan Arellanes ranch, 1 mile west of Casmalia, and the purchase in August by the Pan American Petroleum Investment Corporation of the Bell ranch, a 10,000-acre tract near Los Alamos, south of the Cat Canyon field, were the principal events of the year in this district. Drilling was commenced in five test wells on the latter property before the end of 1916.

Two additional tests of much potential importance were started in the Santa Maria district by the Standard Oil Co. of California. They were located on a tract of 3,700 acres known as the Pezzoni and Tognazzini ranches, a few miles back from the ocean between Casmalia and Guadalupe, in the northwest corner of Santa Barbara County. At the end of 1916 each of these tests had attained depths in excess of 3,000 feet.

In the old ocean-beach field at Summerland the influence of higher prices for crude oil brought about a cleaning of the old wells that resulted in a gain of more than 100 per cent in output compared with 1915.

Ventura County.—Normal activity prevailed in 1916 in the scattered fields in Ventura County, the net effect on production being a 3 per cent gain compared with 1915. Development work was especially active in the Bardsdale field, 3 miles south of Fillmore, where the deepening of wells to the lower sand found in 1915 was the feature of the activity. Five miles southwest of the Bardsdale field oil was found in a test well drilled by the Santa Paula Oil Co. on the crest of the Oak Ridge anticline in the southern part of sec. 18, T. 3 N., R. 20 W., and other tests were started.

Acquisition by the Pan American Petroleum Investment Co. of the producing property of the Bard Oil & Asphalt Co. and the adjacent untested acreage in the Upper Ojai Valley and by the Shell Co. of California of considerable untested land north of Ventura assured an early and thorough development of the oil resources of the western end of the Ventura County district.

Near Ventura interest was sustained throughout the year in the activities of the State Consolidated Oil Co. on the east side of Ventura River, 2 miles north of town.

The discovery of light-gravity oil in this well in October, 1915, at a depth of about 2,470 feet resulted in unsuccessful efforts extending over a period of several months to complete the well and in the eventual drilling of a second well. During preparations in September to cement a water sand at a depth of about 2,250 feet in well No. 2, a

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blow-out occurred that forced mud, water, and gas from the well in such violence as to undermine and overturn the derrick and to engulf a part of the machinery in the crater formed. With the water from this well there came also a considerable quantity of 52° Baumé gravity oil from a sand penetrated in the course of drilling at a depth of about 2,200 feet. The well continued flowing water and oil during the remainder of 1916, an average of 40 barrels of oil a day being skimmed from the sumps in which the mixture was allowed to settle and marketed at prices considerably in advance of those brought by other grades of oil produced in the Ventura County fields. At the end of 1916 work was still in progress on well No. 1 and had been started on well No. 3, the latter on the Hartman lease adjoining the Floyd tract on which Nos. 1 and 2 were drilled.

No additional wells were drilled in 1916 in the vicinity of the well producing light-gravity oil that was completed in 1915 by the Santa Clara Oil & Development Co., in the Santa Paula district.

San Diego County.—Drilling was continued intermittently in 1916 in the deep test of the Balboa Oil Co., in Mission Valley, just north of San Diego, and in the well of the Otay Oil Co., on the south side of Otay Valley, 10 miles southwest of San Diego.

MARKETED PRODUCTION.

Petroleum marketed in California, 1876–1916.

Year.	Production (barrels).	Percentage of total production.	Increase or decrease.		Value.	Yearly average price per barrel.
			Barrels.	Per cent.		
1876	12,000	0.13			$30,000	$2.500
1877	13,000	.10	+ 1,000	+ 8.33	32,500	$2.500
1878	15,227	.10	+ 2,227	+ 17.13	35,174	2.309
1879	19,858	.10	+ 4,631	+ 30.41	45,872	2.310
1880	40,552	.15	+ 20,694	+104.21	93,675	2.309
1881	99,862	.36	+ 59,310	+146.26	230,727	2.310
1882	128,636	.42	+ 28,774	+ 28.81	297,149	2.309
1883	142,857	.61	+ 14,221	+ 11.06	330,000	2.310
1884	262,000	1.08	+ 119,143	+ 83.40	605,220	2.310
1885	325,000	1.49	+ 63,000	+ 24.46	750,750	2.310
1886	377,145	1.34	+ 52,145	+ 16.05	870,205	2.307
1887	678,572	2.39	+ 301,427	+ 79.92	1,567,501	2.310
1888	690,333	2.50	+ 11,761	+ 1.73	1,390,066	2.014
1889	303,220	.86	− 387,113	− 56.08	356,048	1.174
1890	307,360	.67	+ 4,140	+ 1.37	384,200	1.251
1891	323,600	.59	+ 16,240	+ 5.28	401,264	1.240
1892	385,049	.76	+ 61,449	+ 18.99	561,333	1.458
1893	470,179	.97	+ 85,130	+ 22.11	608,092	1.293
1894	705,969	1.43	+ 235,790	+ 50.15	823,423	1.166
1895	1,208,482	2.28	+ 502,513	+ 71.18	849,062	.703
1896	1,252,777	2.05	+ 44,295	+ 3.67	1,240,990	.991
1897	1,903,411	3.15	+ 650,634	+ 51.93	1,713,102	.900
1898	2,257,307	4.08	+ 353,796	+ 18.59	1,917,596	.850
1899	2,642,095	4.63	+ 384,888	+ 15.67	2,508,751	.950
1900	4,324,484	6.80	+ 1,682,389	+ 63.67	4,076,975	.943
1901	8,786,330	12.66	+ 4,461,846	+103.17	4,974,540	.566
1902	13,984,268	15.75	+ 5,197,938	+ 59.16	4,873,617	.348
1903	24,382,472	24.27	+10,398,204	+ 74.36	7,399,349	.303
1904	29,649,434	25.33	+ 5,266,962	+ 21.60	8,265,434	.279
1905	33,427,473	24.81	+ 3,778,039	+ 12.74	8,201,846	.245
1906	33,098,598	26.17	− 328,875	− .98	9,553,430	.289
1907	39,748,375	23.98	+ 6,649,777	+ 20.09	14,699,956	.370
1908	44,854,737	25.13	+ 5,106,362	+ 12.87	23,433,502	.523
1909	55,471,601	30.29	+10,616,864	+ 23.67	30,756,713	.554
1910	73,010,560	34.84	+17,538,959	+ 31.62	35,749,473	.490
1911	81,134,391	36.80	+ 8,123,831	+ 11.13	38,719,080	.477
1912	[a] 87,272,593	39.15	+ 6,138,202	+ 7.57	39,624,501	.454
1913	97,788,525	39.356	+10,515,932	+ 12.05	45,709,400	.467
1914	99,775,327	37.54	+ 1,986,802	+ 2.03	48,066,096	.482
1915	86,591,535	30.81	−13,183,792	− 13.21	36,558,439	.422
1916	90,951,936	30.24	+ 4,360,401	+ 5.04	53,702,733	.590
	918,817,080	23.455			432,008,404	.470

[a] Includes small quantity from Alaska.

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Petroleum marketed in California in 1915 and 1916.

District and county.	1915			1916		
	Quantity (barrels).	Value.	Price per barrel.	Quantity (barrels).	Value.	Price per barrel.
Coastal and southern:						
Los Angeles County:						
Los Angeles city	164,873	$81,011	$0.491	209,781	$180,386	$0.602
Newhall	112,499	66,704	.593	108,590	89,947	.828
Salt Lake	1,738,147	639,487	.368	1,457,471	867,319	.596
Puente, Whittier	716,731	337,219	.471	979,836	643,313	.657
Orange County:						
Fullerton[a]	11,885,150	5,895,572	.496	13,089,865	8,515,879	.651
Ventura County:						
Santa Paula	908,359	641,878	.707	932,028	705,543	.757
Santa Barbara County:						
Lompoc, Santa Maria	4,272,630	1,976,384	.463	4,439,619	2,321,186	.523
Summerland	18,314	9,955	.544	42,223	29,267	.693
Monterey County, San Luis Obispo County, Santa Clara County	37,617	20,230	.538	45,608	25,792	.566
San Joaquin Valley:						
Fresno County:						
Coalinga	12,851,034	5,142,990	.400	14,231,251	8,460,623	.595
Kern County:						
Kern River	7,585,400	2,854,962	.376	8,226,788	4,528,711	.550
Lost Hills	3,124,082	1,365,538	.437	3,433,034	1,829,710	.533
McKittrick[b]	4,515,813	1,905,400	.422	4,467,668	2,692,120	.603
Midway	29,930,003	12,196,056	.407	31,840,361	18,570,505	.583
Sunset	8,730,883	3,423,863	.392	7,357,818	4,242,432	.577
	53,886,181	21,747,019	.411	55,325,669	31,863,478	.576
Grand total	86,591,535	36,558,439	.422	90,951,936	53,702,733	.590

[a] Includes Coyote Hills. [b] Includes Belridge.

Petroleum marketed in California, 1907–1916, by counties, in barrels.

Year.	Fresno.	Kern.	Los Angeles.	Orange.	Santa Barbara.	Ventura.	San Mateo.	Santa Clara.	Total.
1907	8,871,723	15,652,156	3,477,235	2,604,982	8,708,077	357,094	[a] 77,108		39,748,375
1908	10,386,168	18,132,893	4,692,495	3,358,714	7,816,682	379,044	[a] 88,741		44,854,737
1909	14,795,459	23,831,768	16,774,195				[a] 70,179		55,471,601
1910	18,387,750	37,896,727	16,665,678				[b] 60,405		73,010,560
1911	18,483,751	45,921,712	16,708,466				[b] 20,462		81,134,391
1912	19,911,820	50,245,255	[c] 17,095,395				[b] 20,123		87,272,593
1913	19,302,054	58,278,966	20,164,689				[b] 42,216		97,788,525
1914	15,692,783	62,429,243	3,150,892	13,260,226	4,363,797	857,685	[d] 20,751		99,775,327
1915	12,851,034	53,886,181	2,732,250	11,885,150	4,290,944	906,359	[d] 37,617		86,591,535
1916	14,231,251	55,325,669	2,945,678	13,089,865	4,481,842	932,028	[b] 45,603		90,951,936

[a] Includes oil produced in San Luis Obispo County.
[b] Production of Santa Clara and San Luis Obispo counties.
[c] Includes small quantity from Alaska.
[d] Includes Monterey County.

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Petroleum marketed in California in 1915 and 1916, with increase or decrease.

District and county.	Marketed production (barrels).		Increase or decrease.	
	1915	1916	Barrels.	Per cent.
Coastal and southern:				
Los Angeles County:				
Los Angeles City	164,873	299,781	+ 134,908	+ 81.83
Newhall	112,499	108,590	− 3,909	− 3.47
Salt Lake	1,738,147	1,457,471	− 280,676	− 16.15
Puente, Whittier	716,731	979,836	+ 263,105	+ 36.71
Orange County:				
Fullerton[a]	11,885,150	13,089,865	+1,204,715	+ 10.14
Ventura County:				
Santa Paula	908,359	932,028	+ 23,669	+ 2.61
Santa Barbara County:				
Lompoc, Santa Maria	4,272,630	4,439,619	+ 166,989	+ 3.91
Summerland	18,314	42,223	+ 23,909	+130.55
San Luis Obispo County, Santa Clara County	37,617	45,603	+ 7,986	+ 21.23
San Joaquin Valley:				
Fresno County:				
Coalinga	12,851,034	14,231,251	+1,380,217	+ 10.74
Kern County:				
Kern River	7,585,400	8,226,788	+ 641,388	+ 8.46
Lost Hills	3,124,082	3,433,034	+ 308,952	+ 9.89
McKittrick[b]	4,515,813	4,467,668	− 48,145	− 1.07
Midway	29,930,003	31,840,361	+1,910,358	+ 6.38
Sunset	8,730,883	7,357,818	−1,373,065	− 15.73
	53,886,181	55,325,669	+1,439,488	+ 2.67
Grand total	86,591,535	90,951,936	+4,360,401	+ 5.04

[a] Includes Coyote Hills. [b] Includes Belridge.

Petroleum marketed, value, and average price per barrel in California, 1907–1916.

Year.	Coastal and southern.			San Joaquin Valley.			Total.		
	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.	Quantity (barrels).	Value.	Average price per barrel.
1907	24,523,879	$7,393,036	$0.301	15,224,496	$7,306,920	$0.4799	39,748,375	$14,699,956	$0.370
1908	16,335,676	9,296,743	.569	28,519,061	14,136,759	.4956	44,854,737	23,433,502	.523
1909	16,844,374	9,737,616	.578	38,627,227	21,019,097	.544	55,471,601	30,756,713	.554
1910	16,726,083	10,532,080	.629	56,284,477	25,217,393	.448	73,010,560	35,749,473	.490
1911	16,728,928	10,607,280	.904	64,405,463	28,111,800	.436	81,134,391	38,719,080	.477
1912	[a]17,115,518	[a]10,454,186	.615	70,157,075	29,170,315	.416	87,272,593	39,624,501	.454
1913	20,206,905	11,293,794	.557	77,581,620	34,435,606	.444	97,788,525	45,709,400	.467
1914	31,653,351	13,047,568	.603	78,121,976	35,018,528	.448	99,775,327	48,066,096	.482
1915	19,854,320	9,668,430	.486	66,737,215	26,890,009	.403	86,591,535	36,558,439	.422
1916	21,395,016	13,378,632	.625	69,556,920	40,324,101	.580	90,951,936	53,702,733	.590

[a] Includes small quantity from Alaska.

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FIELD REPORT.

Field report for oil industry in California in 1915 and 1916.

County and district.	Wells.					Acreage.		
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
		Oil.	Dry.					
1915.								
Fresno County	1,071	20	1	5	1,086	26,073	8,819	34,892
Kern County:								
Kern River	1,757	22	.....	15	1,764	12,595	5,040	17,635
Lost Hills	160	11	2	2	169	11,148	1,920	13,068
McKittrick	371	15	.....	.....	386	39,718	497	40,215
Midway	1,205	109	6	9	1,305	19,690	25,391	45,081
Sunset	407	11	.....	12	406	12,533	10,957	23,490
Los Angeles County:								
Los Angeles city	378	1	.....	1	378	150	35	185
Newhall-Puente	124	2	.....	.....	126	638	1,546	2,184
Salt Lake	312	1	.....	17	296	639	779	1,418
Whittier	130	6	1	8	128	2,493	1,137	3,630
Orange County	395	43	4	9	434	10,535	10,847	21,382
Riverside County	.....	.....	1	.....	.....	85	400	485
San Luis Obispo County	5	.....	.....	.....	5	6,298	120	6,418
San Mateo County	4	.....	.....	4	.....	.....	.....	.....
Santa Clara County	5	1	.....	.....	6	253	6,203	6,456
Santa Barbara County:								
Lompoc-Santa Maria	292	13	1	4	301	86,868	42,392	129,260
Summerland	134	1	.....	.....	135	12	3	15
Ventura County	382	10	2	3	389	75,112	33,244	108,356
Miscellaneous	.....	.....	2	.....	.....	.....	1,212	1,212
	7,132	272	20	90	7,314	304,840	150,542	455,382
1916.								
Fresno County	1,086	54	2	31	1,109	21,701	4,810	26,511
Kern County:								
Kern River	1,764	102	14	9	1,857	11,843	5,144	16,987
Lost Hills	169	101	1	1	269	9,138	2,205	11,343
McKittrick	386	40	3	5	421	11,564	36,127	47,691
Midway	1,305	190	2	17	1,478	24,410	33,378	57,788
Sunset	406	20	1	6	420	13,749	1,645	15,394
Los Angeles County:								
Los Angeles City	378	.....	.....	.....	378	51	21	72
Newhall-Puente	126	3	.....	8	121	4,860	1,467	6,327
Salt Lake	296	.....	.....	16	280	975	779	1,754
Whittier	128	11	.....	1	138	2,648	1,137	3,785
Orange County	434	57	2	9	482	14,257	17,338	31,595
San Luis Obispo County	5	.....	.....	.....	5	120	1,280	1,400
Santa Clara County	6	1	2	.....	7	200	6,000	6,200
Santa Barbara County:								
Lompoc-Santa Maria	301	13	.....	6	308	26,116	30,289	56,405
Summerland	135	.....	.....	8	127	10	4	14
Ventura County	389	21	4	26	384	12,323	20,952	33,275
Miscellaneous	.....	.....	1	.....	.....	120	910	1,030
	7,314	613	32	143	7,784	154,085	163,496	317,571

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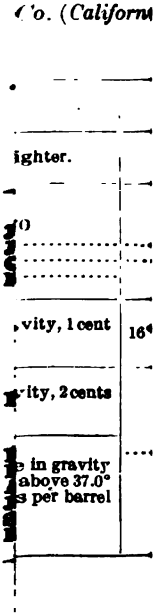

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MICHIGAN, MISSOURI, AND ALASKA.

Petroleum production in Michigan decreased 35 per cent in 1916 compared with 1915. The output, which has never been large, consisted in 1916 of natural lubricating oil from a few shallow wells near Port Huron, St. Clair County.

Oil in commercial quantities was produced in Missouri in 1916 at only one locality—in Jackson County. The output was less than in 1915.

Production of petroleum in Alaska in 1916 was restricted to six wells in the Katalla district, the output of which was about 40 per cent less than in 1915. In the early part of the year the producing properties in this district and the small refinery at Katalla were taken over by the St. Elias Oil Co., which plans additional development work.

MARKETED PRODUCTION.

Petroleum marketed in Missouri, 1889–1916.

Year.	Quantity (barrels).	Percentage of total production.	Increase or decrease.		Value.	Average yearly price per barrel.
			Barrels.	Per cent.		
1889	20				$40	$2.000
1890	278		+ 258	+1,290.00	556	2.000
1891	25		− 253	− 91.01	84	3.360
1892	10		− 15	− 60.00	40	4.000
1893	50		+ 40	+ 400.00	154	3.080
1894	8		− 42	− 84.00	40	5.000
1895	10		+ 2	+ 25.00	50	5.000
1896	43		+ 33	+ 330.00	185	4.300
1897	19		− 24	− 55.81	174	9.158
1898	10		− 9	− 47.37	105	10.500
1899	132		+ 122	+1,220.00	205	1.553
1900	[a] 1,602		+ 1,470	+1,113.64	1,177	.735
1901	[a] 2,335		+ 733	+ 45.76	2,600	1.114
1902	[a] 757		− 1,578	− 67.58	1,066	1.408
1903	[a] 3,000		+ 2,243	+ 296.30	4,650	1.550
1904	[a] 2,572		− 428	− 14.27	4,769	1.854
1905	[a] 3,100		+ 528	+ 20.53	3,320	1.071
1906	[a] 3,500		+ 400	+ 12.90	4,890	1.397
1907	[a] 4,000		+ 500	+ 14.28	6,500	1.625
1908	[a] 15,246		+11,246	+ 281.15	22,345	1.466
1909	[a] 5,750		− 9,496	− 62.28	7,830	1.362
1910	[a] 3,615		− 2,135	− 37.13	4,794	1.326
1911	[a] 7,995		+ 4,380	+ 121.16	7,995	1.000
1912	[b]					
1913	[c] 10,843	0.004	+10,843		19,263	1.777
1914	[d] 7,792		− 3,051	− 28.14	14,291	1.834
1915	[d] 14,265	.005	+ 6,473	+ 83.07	24,295	1.703
1916	[d] 7,705	.003	− 6,560	− 45.99	14,410	1.870
	94,682	.002			145,828	1.540

[a] Includes Michigan.
[b] No production for Missouri; Michigan included in Lima, Ohio.
[c] Includes Alaska, Michigan, and New Mexico.
[d] Includes Alaska and Michigan.

OTHER STATES.

Alabama.—Nothing of consequence resulted from the quest for petroleum in Alabama in 1916. Late in December the discovery of oil in small quantities near Cordova, Walker County, furnished the basis for considerable local excitement, which, however, failed to result in the opening of a new field. So-called gas blow-outs near Mobile provided an incentive for drilling in that locality and at the end of 1916 tests were under way west of that city.

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Arizona.—Drilling in Tonto Basin and in Verde Valley was continued in 1916 but failed to disclose the presence of oil in commercial quantities in either locality. Renewed activity in the Virgin River district in southwestern Utah aroused interest in possibilities of oil in adjoining parts of Mohave County, Ariz., but resulted in no drilling.

Arkansas.—The successful development of an important gas field in Crawford County, known as the Kibler field, 7 miles east of Van Buren, was the only feature of importance to the oil and gas industry in Arkansas in 1916. The impetus given by this development to wildcat drilling for oil in Arkansas included many counties in its scope, but to the end of 1916 no discoveries of importance had been made.

Florida.—The finding of traces of oil at a depth of 950 feet in a well drilled in December by the Bonheur Development Co., near Wakulla, Wakulla County, about 12 miles south of Tallahassee, aroused considerable interest in the possibilities of oil in western Florida.

Idaho.—Numerous pockets of gas were penetrated in a well drilled in 1916 by the Weiser Oil & Gas Co., at Weiser, Washington County, Idaho, but no oil was found.

Mississippi.—The deep test of the Mississippi Oil, Gas, & Investment Co., on the Ferguson tract, near Vicksburg, Warren County, Miss., was abandoned, dry, in November, at a reported depth of 3,370 feet.

Nebraska.—A deep test drilled in 1916 by E. F. Schrom and others, near Plattsmouth, Cass County, Nebr., was abandoned, dry, in September at a reported depth of about 3,000 feet. No oil or gas was found.

New Jersey.—The reported discovery of oil in November, at a depth of 800 feet, in a well drilled on the Steelman farm, 4 miles east of Millville, Cumberland County, brought considerable notoriety to a locality in which geologic conditions, as promptly announced by the State geologist, are unfavorable to the occurrence of oil in commercial quantities.

New Mexico.—Interest in the possibilities of oil in New Mexico resulted in the leasing of land in various parts of the State and the making of preparations for active drilling in 1917. Drilling was begun by Kniflin and others in one test, 4 miles southeast of Columbus, in Luna County.

Virginia.—Drilling for oil near Richmond and Petersburg, along the Coastal Plain of Virginia, resulted in disappointment, as only pockets of marsh gas were found.

Washington.—Gas in small volume was found at a depth of 104 feet in a well on the Ivison farm near Ephrata, Grant County, Wash., by the Grant County Oil & Gas Co.

IMPORTS.[1]

Despite the fact that the United States leads the other countries of the world in the production of crude petroleum, its import trade in petroleum and its derivatives is steadily increasing. The bulk of its imports consists of crude petroleum from Mexico for use as rail-

[1] Statistics of imports and exports were compiled by J. A. Dorsey, of the U. S. Geological Survey, from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

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road and industrial fuel and in the manufacture of asphalt, the availability and relative cheapness of the Mexican petroleum being factors that tend to extend its usefulness for these purposes. The increased use of the low-grade asphaltic oils of the Gulf field of Texas and Louisiana both for the manufacture of lubricants and to a less extent for motor fuels has in the last two years greatly stimulated the demand for Mexican fuel oil in the southern part of the United States to replace the fuel formerly obtained from domestic sources.

The recovering demand in the United States for mineral waxes of all kinds to satisfy the augmented demands of varied war industries is also reflected in the accompanying statistics.

Petroleum, paraffin oil, and ozokerite and paraffin wax imported for consumption in the United States, 1912–1916.

Year.	Petroleum.		Paraffin oil.		Ozokerite and paraffin wax.		Total value.
	Quantity (barrels).	Value.	Quantity (barrels).	Value.	Quantity (pounds).	Value.	
1912	7,383,229	$6,082,881	2,571	$32,565	17,617,068	$985,959	$7,101,405
1913	17,309,068	12,947,280	3,676	49,458	16,051,322	932,894	13,929,632
1914	17,247,483	11,465,466	2,481	36,687	15,516,242	824,234	12,326,387
1915	18,140,110	10,339,012	1,707	85,121	10,259,445	553,397	11,027,530
1916	20,570,075	12,602,811	902	75,925	12,266,191	706,874	13,385,610

Gross imports of petroleum and petroleum products into the United States in 1915 and 1916.

Kind and source.	1915		1916	
	Quantity.	Value.	Quantity.	Value.
Crude petroleum:	*Gallons.*		*Gallons.*	
Canada	18,150	$713	201,615	$17,866
Mexico	734,095,839	9,760,859	845,277,611	11,775,377
Cuba			1,148,280	15,037
Trinidad and Tobago	12,248,825	281,729	18,122,063	323,518
Panama	186,259	2,217		
Peru	15,254,994	403,807	8,718,774	442,468
Argentina	1,678	56		
China	85	2		
Hongkong	1,350	20		
Japan	45,000	1,150		
	761,852,180	10,387,553	873,468,333	12,574,266
Benzine, gasoline, and naphtha:				
Canada	2,188	321	370	113
Mexico	1,134,080	34,301	100	20
Cuba			350	93
Peru			2,702,555	185,060
England	10,410	4,134		
	1,146,678	38,756	2,703,375	185,286
Mineral wax (ozokerite and ceresine):	*Pounds.*		*Pounds.*	
Canada	6,542	1,434	238,997	17,323
Dominican Republic			160	40
Brazil			1,760	344
England	573,931	42,703	1,504,372	114,094
Austria-Hungary	285,115	42,595		
Germany	1,579,057	105,868		
Italy			625	144
Netherlands	104,314	5,930		
Denmark	4,255	264		
Japan			22,400	2,133
British India	276,448	12,436	1,279,520	66,299
British South Africa	15,642	3,265		
	2,845,304	214,495	3,047,834	200,377

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Gross imports of petroleum and petroleum products into the United States in 1915 and 1916—Continued.

Kind and source.	1915		1916	
	Quantity (gallons).	Value.	Quantity (gallons).	Value.
Paraffin wax:				
Canada	168,597	$5,567	1,368,783	$61,685
Germany	131	21	.....	.....
Netherlands	192,500	8,212	.....	.....
England	990,897	49,786	4,995,916	282,476
Scotland	13,440	681	80,880	4,231
China	224,000	10,464	740,723	36,691
British India	2,825,970	130,095	454,720	22,017
Japan	.....	.....	419,123	45,756
Dutch East Indies	2,997,093	135,567	1,009,630	46,616
Straits Settlements	.....	.....	188,340	11,217
	7,412,628	340,393	9,258,115	510,689

EXPORTS.

TERRITORIAL SHIPMENTS.

The market for petroleum and its products in Alaska and in the insular possessions of the United States has greatly expanded in the last decade, as is shown by the following statistical summary:

Petroleum products shipped to Alaska from other parts of the United States, 1907–1916.

Year.	Oil used for fuel, including crude, gas oil, and residuum.		Gasoline, including all lighter products of distillation.		Illuminating.		Lubricating.	
	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.
1907	9,104,300	$143,506	636,881	$119,345	510,145	$99,342	100,145	$37,929
1908	11,891,375	176,483	939,424	147,104	566,598	102,567	94,542	36,423
1909	14,119,102	340,225	746,930	118,810	531,727	98,786	85,687	35,382
1910	19,143,091	506,200	788,154	136,569	626,972	95,483	104,512	38,625
1911	20,878,843	485,279	1,238,865	167,915	423,750	57,896	100,141	34,048
1912	15,523,555	309,804	2,736,739	344,739	672,176	100,722	154,565	60,949
1913	15,682,412	453,756	1,735,658	272,661	661,656	106,603	150,918	61,966
1914	18,601,384	404,349	2,878,723	373,607	731,146	103,779	191,878	74,535
1915	16,910,012	476,564	2,413,962	243,712	513,075	82,105	271,981	101,988
1916	23,555,811	657,976	2,844,801	378,267	732,969	108,174	373,046	132,902

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Petroleum products shipped to Hawaii, the Philippines, and Porto Rico, 1907–1916.

Year.	Oil used for fuel, including crude, gas oil, and residuum.		Gasoline, including all lighter products of distillation.		Illuminating.		Lubricating.	
	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.
HAWAII.								
1907	38,916,400	$581,905	484,435	$73,405	1,441,037	$230,968	355,451	$104,930
1908	47,719,900	802,325	648,310	91,351	1,143,591	179,507	358,282	140,157
1909	43,764,041	871,485	804,169	127,076	1,401,381	232,340	367,831	121,282
1910	54,539,511	1,095,549	974,268	160,700	1,359,671	226,481	359,528	133,968
1911	47,250,018	949,409	1,329,589	203,052	1,587,373	220,505	466,826	138,927
1912	58,790,343	1,182,230	2,501,938	343,062	1,817,718	190,939	477,012	165,993
1913	60,066,083	1,154,188	2,058,091	315,333	1,807,288	210,997	456,477	145,455
1914	67,893,460	1,207,036	3,162,667	364,260	2,157,021	250,158	408,606	147,243
1915	72,795,931	1,256,003	3,546,351	379,134	1,966,448	227,212	569,032	193,821
1916	67,771,683	1,397,398	5,136,021	803,461	1,842,793	232,216	612,938	197,496
PHILIPPINES.								
1907	.....	.....	79,560	12,930	8,218,400	842,111	181,504	32,598
1908	4,504	322	140,550	21,775	9,234,263	967,284	257,800	61,571
1909	21,789	1,581	184,390	23,428	5,995,090	558,642	362,068	81,278
1910	13,708	1,122	318,070	42.058	10,643,804	862,496	432,867	95,213
1911	5,502	376	1,074,615	158,592	11,653,570	913,760	470,832	107,499
1912	106,872	5,358	1,326,040	216,810	12,634,519	1,094,596	487,607	121,999
1913	10,370	1,013	1,414,225	280,690	12,091,810	1,142,403	517,494	105,001
1914	11,408	564	1,197,774	206,754	12,906,403	1,219,404	971,977	189,279
1915	12,427	366	1,483,534	241,273	8,524,833	731,026	784,192	157,925
1916	14,819	528	2,226,026	631,541	8,539,700	809,014	645,329	148,443
PORTO RICO.								
1907	.....	.....	219,691	38,003	1,700,838	176,808	223,389	53,599
1908	25,437	2,118	285,188	45,479	1,623,477	189,021	264,012	65,776
1909	7,566	475	495,367	93,649	1,931,676	216,316	218,829	78,963
1910	8,739	499	874,814	135,290	1,973,389	222,108	238,935	91,356
1911	51,656	2,899	1,106,327	133,470	2,323,401	207,804	479,579	117,034
1912	29,204	1,857	1,470,105	223,325	2,168,105	212,043	471,596	134,882
1913	21,108	1,439	1,580,772	303,012	2,381,187	246,137	507,412	120,007
1914	53,586	4,939	1,836,896	320,163	2,227,195	227,500	361,117	80,247
1915	65,447	3,337	2,401,695	449,044	2,426,133	219,148	391,245	88,081
1916	182,722	7,428	2,811,843	727,466	2,168,303	207,976	520,092	119,121

FOREIGN SHIPMENTS.

The foreign trade of the United States in petroleum and its liquid products in the calendar year 1916 shows gain of 12 per cent in quantity and of 41 per cent in declared value over that in 1915 and establishes a record for annual exports of mineral oils. This gain, which reflects not only augmented foreign demand resulting from the war but increased facilities for the ocean transport that made possible the satisfaction of a larger percentage of such demands, applied in 1916 to each of the principal classes of mineral oils exported. Gains in quantity in 1916 over 1915 were 9 per cent on crude petroleum, 26 per cent on gasoline and naphtha, 2 per cent on illuminating oils, 9 per cent on lubricants, and 19 per cent on gas oil, fuel oil, and residuum.

Corresponding gains in declared value amounted to 64 per cent on crude petroleum, 102 per cent on gasoline and naphtha, 12 per cent on illuminating oils, 33 per cent on lubricants, and 22 per cent on gas oil, fuel oil, and residuum.

The following tables have been compiled from the records of the Bureau of Foreign and Domestic Commerce:

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Mineral oils exported from the United States in 1915 and 1916, by months.

Month.	1915		1916	
	Quantity (gallons).	Value.	Quantity (gallons).	Value.
January	148,372,006	$8,872,086	173,131,096	$11,712,621
February	152,997,597	9,232,553	179,829,436	12,004,278
March	168,396,321	10,750,210	220,197,353	16,272,472
April	170,811,299	11,407,548	157,461,216	12,542,136
May	218,420,565	13,133,539	231,344,348	18,194,760
June	211,479,373	13,449,791	223,236,006	19,594,723
July	217,383,156	12,913,406	255,835,136	21,703,826
August	233,444,401	14,069,644	253,039,351	22,203,177
September	215,623,617	12,421,784	208,566,822	20,967,053
October	205,323,026	11,467,090	224,207,595	16,415,489
November	187,871,072	12,571,643	205,697,021	15,039,027
December	198,601,316	12,652,365	216,935,286	15,051,727
	2,328,725,749	142,941,669	2,607,482,366	201,721,291

Mineral oils exported from the United States in 1915 and 1916, by kinds and ports.

Kind and port.	1915		1916	
	Quantity.	Value.	Quantity.	Value.
CRUDE.	*Barrels.*		*Barrels.*	
New York	216,519	$673,581	195,802	$776,791
Philadelphia				
Galveston	13	30	1,182	4,096
Other districts	3,551,636	3,609,216	3,898,918	6,249,036
	3,768,168	4,282,827	4,095,902	7,029,923
GASOLINE AND NAPHTHA.	*Gallons.*		*Gallons.*	
Baltimore	35,539	4,167	59,501	16,153
Boston and Charlestown	63,552	10,672	131,132	32,546
New York	160,512,887	20,716,994	125,315,453	19,719,362
Philadelphia	25,588,526	2,950,289	54,644,646	11,493,731
Galveston	45,447	5,637	1,099,166	260,401
Other districts	95,363,130	10,197,288	174,630,385	37,148,688
	281,609,081	33,885,047	355,870,283	68,660,881
ILLUMINATING.				
Baltimore	191,565	15,437	341,469	37,780
Boston and Charlestown	89,556	10,207	209,822	22,761
New York	409,872,429	27,649,700	406,509,854	31,162,685
Philadelphia	101,787,388	5,415,300	144,219,860	8,454,999
Galveston	90,000	8,550	494,740	26,958
Other districts	324,927,727	16,889,403	302,922,659	16,157,723
	836,958,665	49,988,597	854,688,404	55,862,906
LUBRICATING AND PARAFFIN.				
Baltimore	6,038,137	746,444	7,689,303	1,170,577
Boston and Charlestown	306,457	52,531	132,131	30,852
New York	165,782,388	23,271,302	165,834,102	28,684,442
Philadelphia	51,935,306	5,604,446	67,016,667	9,709,701
Galveston	70,513	11,461	181,195	19,004
Other districts	15,545,924	2,773,457	19,962,541	3,412,795
	239,678,725	32,459,641	260,805,939	43,027,371
GAS OIL AND FUEL OIL.[a]				
Baltimore	2,150,663	61,461	106,221	11,388
Boston and Charlestown	5,632	261	1,777	134
New York	101,860,915	3,099,229	63,314,799	2,654,209
Philadelphia	22,292,058	729,228	30,581,480	1,218,422
Galveston	50	3		
Other districts	685,906,891	18,435,375	870,085,560	23,256,057
	812,216,209	22,325,557	964,089,837	27,140,210
Grand total (gallons)	2,328,725,749	142,941,669	2,607,482,366	201,721,291

[a] Includes residuum and excludes fuel or bunker oil in vessels engaged in the foreign trade, which aggregated in 1915, 3,565,805 barrels, valued at $3,161,341, and in 1916, 5,529,787 barrels, valued at $5,583,222.

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Mineral oils exported from the United States in 1915 and 1916, by kinds and ports—Continued.

Recapitulation by kinds.

Kind and port.	1915		1916	
	Quantity.	Value.	Quantity.	Value.
	Gallons.		*Gallons.*	
Crude	158,263,069	$4,282,827	172,027,903	$7,029,922
Naphtha	281,609,081	33,885,047	355,870,283	68,660,881
Illuminating	336,958,655	49,988,597	854,688,404	55,862,906
Lubricating and paraffin	239,678,725	32,459,641	260,805,939	43,027,371
Gas oil and fuel oil [a]	812,216,209	22,325,557	964,089,837	27,140,211
	2,328,725,749	142,941,669	2,607,482,366	201,721,291

Recapitulation by ports.

	Gallons.		*Gallons.*	
Baltimore	8,415,904	$327,509	8,196,494	$1,235,898
Boston and Charlestown	466,197	73,671	474,862	86,393
New York	847,122,431	75,410,806	769,187,886	32,907,489
Philadelphia	201,603,278	14,699,263	296,462,653	30,876,853
Galveston	206,530	25,681	1,804,749	300,459
Other districts	1,270,912,409	51,904,739	1,531,355,722	86,224,299
	2,328,725,749	142,941,669	2,607,482,366	201,721,291

Mineral oils exported from the United States in 1915 and 1916, by kinds and destinations.

Kind and destination.	1915		1916	
	Quantity.	Value.	Quantity.	Value.
CRUDE.				
North America:	*Barrels.*		*Barrels.*	
Canada	2,597,544	$2,105,815	2,966,659	$4,057,513
Mexico	241,254	353,583	189,821	299,914
Panama	55,427	37,004	11	59
Cuba	234,219	606,427	312,803	1,171,031
South America:				
Chile	22,590	27,013	55,064	44,146
Europe:				
France	17,177	18,087	156,809	460,795
Spain	160,004	452,650	59,498	265,094
Other Europe	99,556	151,775	42,297	104,900
Other countries	330,397	530,458	312,940	626,471
	3,768,168	4,282,827	4,095,902	7,029,923
REFINED.				
Gasoline.				
North America:	*Gallons.*		*Gallons.*	
Canada	33,874,220	2,883,438	25,312,456	4,090,262
South America:				
Argentina	10,348,542	1,562,184	2,579,281	424,652
Brazil	7,593,380	1,196,053	7,470,287	1,612,283
Europe:				
France	14,356,497	1,515,543	44,405,796	9,627,990
Italy	3,651,600	415,422	8,241,455	1,413,985
Netherlands	535,911	64,320	153,290	29,700
United Kingdom	18,926,206	1,986,060	45,530,388	9,216,252
Other Europe	5,619,013	606,016	10,655,903	2,069,037
British Oceania	8,163,752	1,312,651	9,237,065	2,085,348
Other countries	9,491,808	1,579,443	14,341,841	3,095,448
	112,562,929	13,164,159	167,926,262	33,614,957
Naphtha.				
All countries	169,046,152	20,720,888	187,942,021	35,045,924
	281,609,081	33,885,047	355,870,283	68,660,881

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Mineral oils exported from the United States in 1915 and 1916, by kinds and destinations—Continued.

Kind and destination.	1915		1916	
	Quantity.	Value.	Quantity.	Value.
REFINED—continued.				
Illuminating oil.				
North America:	*Gallons.*		*Gallons.*	
Canada	6,292,171	$44,099	9,736,254	$552,106
Cuba	242,761	25,808	1,448,875	144,788
West Indies	6,024,079	636,269	6,506,134	762,149
South America:				
Argentina	15,408,268	1,551,437	12,587,302	1,332,443
Brazil	34,734,254	2,900,468	30,756,971	2,786,581
Chile	5,093,975	460,980	6,465,611	679,752
Other South America	11,970,999	1,205,250	11,385,498	1,194,379
Europe:				
Denmark	28,583,368	1,309,997	32,439,735	1,739,941
France	77,630,112	4,211,725	92,112,121	5,702,579
Italy	30,398,605	1,490,456	37,522,438	2,028,153
Netherlands	60,078,821	2,598,088	55,816,443	2,739,848
Sweden	26,316,321	1,272,324	27,762,077	1,564,332
United Kingdom	161,901,460	7,802,883	151,908,144	8,496,691
Other Europe	46,868,634	2,709,464	59,049,392	4,057,068
Asia:				
China	84,866,476	5,084,713	85,689,334	5,671,757
British India	31,142,201	2,014,499	49,802,870	2,502,805
Hongkong	14,467,706	733,426	21,674,281	1,469,581
Japan	61,208,219	3,210,433	44,223,949	2,377,557
Oceania:				
Dutch East Indies	11,269,844	907,973	11,342,660	1,002,677
British Oceania	36,797,957	3,352,540	27,557,720	2,639,349
Philippine Islands	8,524,833	731,026	8,539,700	809,014
British Africa	14,831,586	1,378,750	17,657,838	1,716,466
Other countries	62,305,925	106,039	52,678,107	3,893,012
	836,958,665	49,988,597	854,688,404	55,862,906
Lubricating and paraffin oil.				
North America:				
Canada	5,715,496	831,296	5,560,526	959,314
Mexico	745,739	184,678	619,608	138,847
Cuba	1,888,835	589,323	2,857,169	973,915
South America:				
Argentina	5,073,168	899,288	6,086,546	1,364,619
Brazil	3,898,928	729,009	3,674,350	839,934
Chile	2,037,617	343,959	2,696,410	560,192
Europe:				
France	38,744,744	4,724,157	56,539,190	8,460,149
Italy	28,200,173	2,921,746	17,019,194	2,606,926
Netherlands	6,469,414	799,510	3,596,943	679,995
United Kingdom	87,672,667	10,544,686	95,951,712	14,866,299
Other Europe	29,028,538	4,065,469	18,837,245	3,301,834
Asia:				
Japan	3,198,906	575,287	3,358,197	639,156
Oceania:				
British East Indies	11,901,180	1,607,398	16,498,674	2,386,514
British Oceania	6,364,060	1,054,157	9,410,414	1,575,261
British Africa	2,634,415	554,042	4,142,524	923,712
Other countries	11,104,845	2,035,641	13,957,237	2,748,704
	239,678,725	32,459,641	260,805,939	43,027,371
Gas oil and fuel oil.[a]				
All countries	799,589,047	21,961,176	957,602,259	26,990,552
Residuum, including tar.				
All countries	12,627,162	364,381	6,487,578	149,658
Total refined	2,170,462,680	138,658,842	2,435,454,463	194,691,968
Total crude and refined (gallons)	2,328,725,749	142,941,669	2,607,482,366	201,721,291

[a] Excludes fuel or bunker oil in vessels engaged in the foreign trade, which aggregated in 1915, 3,565,805 barrels, valued at $3,161,341, and in 1916, 5,529,737 barrels, valued at $5,583,223.

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Petroleum exported from Texas in 1915 and 1916.

1915.

Customs district.	Crude, including all natural oils.			Naphtha.		Illuminating.	
	Quantity.		Value.	Quantity.	Value.	Quantity.	Value.
	Barrels.	*Gallons.*		*Gallons.*		*Gallons.*	
Laredo	11,114	466,807	$7,821	37,088	$6,534	106,528	$12,067
Galveston	12	520	30	45,447	5,637	90,000	8,550
Sabine	97,268	4,085,242	141,480	26,920,363	3,144,250	114,309,779	6,914,439
El Paso	72,181	3,031,599	98,206	167,032	22,033	699,307	79,188
Eagle Pass	90	3,767	175	17,327	2,739	14,697	2,099
	180,665	7,587,935	247,712	27,187,257	3,181,193	115,220,306	7,016,343

Customs district.	Lubricating and heavy paraffin.		Gas oil, fuel oil, and residuum.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Gallons.		*Gallons.*		*Gallons.*	
Laredo	12,784	$4,004	61,055	$1,401	684,257	$31,827
Galveston	70,513	11,461	50	3	206,530	25,681
Sabine	2,435,260	358,945	427,646,347	13,858,457	575,396,991	24,417,571
El Paso	335,032	84,517	.....	.....	4,232,970	283,944
Eagle Pass	20,814	4,253	4,000	160	60,605	9,426
	2,874,403	463,180	427,711,452	13,860,021	580,581,353	24,768,449

1916.

Customs district.	Crude, including all natural oils.			Naphtha.		Illuminating.	
	Quantity.		Value.	Quantity.	Value.	Quantity.	Value.
	Barrels.	*Gallons.*		*Gallons.*		*Gallons.*	
Laredo	4,240	178,079	$4,060	34,863	$8,047	71,222	$9,875
Galveston	1,182	49,648	4,096	1,075,866	248,525	484,740	26,958
Sabine	70,791	2,973,207	194,210	50,194,200	9,092,553	86,871,220	5,623,230
El Paso	8,330	349,842	10,234	426,350	93,990	145,088	21,084
Eagle Pass	17	696	70	30,367	6,983	42,736	5,808
	84,560	3,551,472	212,670	51,761,646	9,450,098	87,614,956	5,686,955

Customs district.	Lubricating and heavy paraffin.		Gas oil, fuel oil, and residuum.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Gallons.		*Gallons.*		*Gallons.*	
Laredo	30,557	$7,850	339,598	$8,943	654,319	$38,775
Galveston	181,195	19,004	.....	.....	1,791,449	298,583
Sabine	3,728,817	612,560	408,463,758	12,819,530	552,231,202	28,342,083
El Paso	30,967	10,487	6,650	205	968,847	136,000
Eagle Pass	34,360	12,567	.....	.....	108,159	25,428
	4,005,896	662,468	408,810,006	12,828,678	555,743,976	28,840,869

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Crude petroleum exported from Pacific ports, including shipments to noncontiguous territories, 1914–1916.

Customs district.	1914		1915		1916	
	Quantity (barrels).	Value.	Quantity (barrels).	Value.	Quantity (barrels).	Value.
From—						
Alaska			1,158	$1,158		
Southern California	297,327	$236,622	105,590	60,747	176,005	$160,159
Washington	103,775	88,741	157,721	126,168	64,725	65,012
Oregon	4	21				
San Francisco	1,963,849	1,470,045	1,975,153	1,440,481	1,903,595	1,630,050
	2,364,955	1,795,429	2,239,622	1,628,554	2,144,325	1,855,221
To—						
Alaska	415,559	319,512	332,623	268,474	446,097	397,327
Brazil	36,524	49,500				
Canada	83,434	72,646	154,364	109,374		
Chile	173,119	131,250	30,000	18,250		
China	41,667	21,000				
Guatemala						
Hawaii	1,614,633	1,201,445	1,636,652	1,174,234	1,610,112	1,383,433
Mexico	18	72	8,422	7,619		
Panama			55,393	36,878		
Salvador			21,680	13,500		
Other	1	4	488	225	88,116	74,461
	2,364,955	1,795,429	2,239,622	1,628,554	2,144,325	1,855,221

The following table exhibits the total marketed production of petroleum from 1907 to 1916, in barrels and in gallons, also the separate derivatives exported and their value, together with their sum and value.

Petroleum marketed in the United States and petroleum products exported, 1907–1916.

Year.	Marketed production.		Exports.			
	Barrels of 42 gallons.	Gallons.	Mineral, crude (including all natural oils, without regard to gravity).		Mineral, refined or manufactured. Naphtha, benzine, gasoline, etc.	
			Quantity (gallons).	Value.	Quantity (gallons).	Value.
1907	166,095,335	6,976,004,070	126,306,549	$6,333,715	34,625,525	$3,676,206
1908	178,527,355	7,498,148,910	149,190,017	6,519,849	43,887,044	4,542,551
1909	183,170,874	7,693,176,708	170,337,773	6,027,588	68,758,675	5,799,994
1910	209,557,248	8,801,404,416	180,111,166	5,404,253	100,695,382	8,407,102
1911	220,449,391	9,258,874,422	201,843,355	6,165,403	137,294,606	11,482,761
1912	222,935,044	9,363,271,848	188,711,420	6,770,484	186,000,094	20,459,378
1913	245,446,230	10,434,741,660	194,469,634	8,448,294	183,043,379	28,091,608
1914	265,762,535	11,162,026,470	124,735,553	4,958,338	209,602,655	26,288,414
1915	281,104,104	11,806,372,368	158,263,069	4,282,827	281,609,081	33,885,047
1916	300,767,158	12,632,220,636	172,027,903	7,029,923	355,870,283	68,660,881

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Petroleum marketed in the United States and petroleum products exported, 1907–1916—Continued.

Year.	Exports—Continued.							
	Mineral, refined or manufactured—Continued.				Residuum (tar, pitch, and all other from which the light bodies have been distilled).		Total exports.	
	Illuminating.		Lubricating (heavy paraffin, etc.).					
	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.
1907	905,924,296	$59,635,208	152,028,855	$19,210,353	75,774,754	$2,527,582	1,294,659,979	$91,383,064
1908	1,129,004,833	75,988,256	147,769,024	18,971,436	77,551,683	2,793,363	1,547,402,601	108,815,455
1909	1,046,401,072	67,814,406	161,639,609	20,016,107	121,966,249	4,180,495	1,569,103,378	103,838,590
1910	940,247,039	55,642,368	163,832,544	20,921,103	117,605,802	3,732,196	1,502,491,933	94,107,022
1911	1,112,295,006	61,055,095	183,319,645	23,337,126	133,979,087	3,882,463	1,768,731,699	105,922,848
1912	1,026,138,239	62,084,022	216,393,206	28,297,467	266,236,938	6,599,031	1,883,479,897	124,210,382
1913	1,119,441,243	72,042,107	207,639,092	29,608,549	426,872,373	11,125,851	2,136,465,721	149,316,409
1914	1,019,449,253	64,112,772	191,647,570	26,316,313	703,508,021	19,224,250	2,240,033,652	139,900,587
1915	836,958,665	49,988,597	239,678,725	32,459,641	812,216,209	22,325,557	2,328,725,749	142,941,669
1916	854,688,404	55,862,906	260,805,939	43,027,371	964,089,837	27,140,210	2,607,482,366	201,721,291

PRICES.

The following tables, compiled from weekly quotations in the Oil, Paint, and Drug Reporter (New York), show the fluctuations in export price of the principal types of illuminating oil and of gasoline entering the foreign trade and, for comparison, the wholesale prices of the same products to domestic jobbers in New York. The quotations on illuminating oil are for 150° F. fire test, water-white kerosene, and on gasoline for the 68° to 72° Baumé grade.

Prices of illuminating oil at New York, 1916.

Export price (cents per gallon).				Jobbing price (cents per gallon).		
Date.	Bulk.	Cases.	Barrels.	Date.	Tank wagon.	Barrels.
Jan. 1	5.00	10.75	8.65	Jan. 1	9.00	13.00
Jan. 4	.....	11.00	.....	Mar. 6	.....	12.00
Jan. 15	5.25	11.25	8.90			
Mar. 31	.....	.....	8.95			
June 1	.....	11.50	.....			
Aug. 4	.....	.....	9.10			
Aug. 11	5.10	11.35	8.95			
Aug. 14	5.00	11.25	8.85			
Sept. 5	4.75	11.00	8.60			
Sept. 12	4.50	10.75	8.35			
Dec. 6	.....	.....	8.65			
Dec. 22	.....	11.75	.....			

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Prices of gasoline at New York, 1916.

Export price (cents per gallon).			Jobbin; price (cents per gallon).		
Date.	10-gallon drum (less than 100 cases).	Cans and cases (less than 100).	Date.	Wooden barrels.	Auto naphtha, to garages only (steel barrels).
Jan. 1	34.00	29.00	Jan. 1	29.00-30.00	21.00
Jan. 14	36.00	31.00	Jan. 5	30.00-31.00	22.00
Feb. 5	37.00	32.00	Feb. 7		23.00
Feb. 25	38.00	33.00	Mar. 2	31.00-32.00	24.00
June 1	38.00	33.25	Aug. 7		23.00
Aug. 11	37.00	32.25	Sept. 7		22.00
Dec. 23	38.00	33.25			

FOREIGN OIL FIELDS.

NORTH AMERICA.

CANADA.

GENERAL STATEMENT.

The output of petroleum in Canada in 1916 was 8 per cent less than in 1915, the decline in 1916 being especially noticeable because of the slight relative increase in production in 1915. The entire output credited to the Canadian fields in 1916 was 198,123 barrels of 35 imperial gallons each.

The average price received at the wells for this oil was $1.98 a barrel and the market value of the output was $392,284, a gain of 58 cents in average unit price and of $91,712, or 30 per cent, over 1915. In addition to their receipts from the sale of this oil its producers received the usual Government bounty of 1.5 cents a gallon on the quantity marketed.

The decline in production in 1916 was almost wholly in the Lambton district in Ontario, the principal area of production, which includes the Petrolia and Oil Springs fields, and was accounted for by the failure of drilling operations to discover enough new production to offset the normal decline in the output of the old wells. The Bothwell field, also in Ontario, is credited with a slight increase in production due to the success of operations in the Thamesville extension, a restricted area of new production which was opened during the year. The stimulating effect of higher prices accounts for the relatively slight gain in output in the Tilbury and Ontario districts. Production in the Belle River district was practically the same as in 1915.

In the old Albert field, in New Brunswick, a revival of activity brought its response in a moderate gain in production. This Province includes deposits of oil shale that are said to yield on distillation from 27 to 52 imperial gallons of crude oil and from 38 to 92 pounds of ammonium sulphate to the long ton. Plans already made for the exploitation of this source of oil are held in abeyance until the close of the war.

In the eastern districts the feature of development in 1916 was the discovery in August of oil having a reported gravity of 52° Baumé in a gas well at Oil Springs, Ontario. Investigation showed that the oil was seeping into the well at a depth of about 1,900 feet in sufficient

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quantities to shut off the normal flow of gas. A subsequent test failed, however, to indicate that commercial production could be obtained at this depth.

In southern Alberta drilling was continued in the Calgary district and farther to the south in the Sweetgrass district, a short distance north of the Montana State boundary. Nothing of consequence was found in the Calgary district, but in the Sweetgrass district further evidence of abundant gas supply was shown.

In British Columbia drilling was continued in the wildcat test of the British Columbia Oilfields (Ltd.) on Graham Island. This well was about 800 feet deep at the end of 1916.

PRODUCTION.

Petroleum produced in Canada, 1907–1916.

[Reported by Canada Geological Survey.]

Year.	Quantity (barrels).[a]	Value.	Average price per barrel.
1907	788,872	$1,057,068	$1.340
1908	527,987	747,102	1.415
1909	420,755	559,604	1.330
1910	315,895	388,550	1.230
1911	291,096	357,073	1.227
1912	243,336	345,050	1.418
1913	228,080	406,439	1.782
1914	[b] 214,805	343,124	1.590
1915	215,464	300,572	1.392
1916	198,123	392,284	1.979

[a] Barrels of 35 imperial gallons. The Canadian barrel of 35 imperial gallons is the practical equivalent of the United States barrel of 42 gallons, the difference being less than 0.03 per cent.
[b] Includes 387 barrels from Alberta.

Petroleum produced in Ontario and New Brunswick, 1912–1916, in barrels.

[Reported by supervisor of petroleum bounties at Petrolia, Ontario.]

District.	1912	1913	1914	1915	1916
Bothwell	34,496	34,349	33,961	33,395	33,856
Dutton	4,335	4,610	2,190	5,401	2,851
Lambton	150,272	155,747	154,186	161,368	142,208
Tilbury and Romney	44,727	26,824	18,530	12,742	16,296
Leamington, Onondaga (Brant County)	7,115	4,172	2,437	1,490	1,663
Belle River		464	1,191	46	
Total Ontario	240,935	226,166	212,495	214,442	196,874
New Brunswick	2,679	2,111	1,725	1,020	1,345
Total Canada	243,614	228,277	214,220	215,462	198,219

PRICES.

Average monthly prices per barrel for crude oil at Petrolia, Ontario, 1912–1916.

Month.	1912	1913	1914	1915	1916	Month.	1912	1913	1914	1915	1916
January	$1.26	$1.681	$1.89	$1.305	$1.846	August	$1.44	$1.790	$1.47	$1.305	$1.927
February	1.35	1.738	1.89	1.305	1.969	September	1.44	1.790	1.45	1.440	1.830
March	1.38	1.761	1.89	1.305	2.072	October	1.44	1.790	1.41	1.480	1.933
April	1.38	1.780	1.80	1.305	2.130	November	1.48	1.831	1.36	1.605	1.930
May	1.40	1.790	1.00	1.305	2.130	December	1.59	1.856	1.36	1.700	1.945
June	1.42	1.790	1.58	1.305	2.130						
July	1.42	1.790	1.56	1.305	2.130	The year	1.42	1.782	1.59	1.395	1.979

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MEXICO.

GENERAL STATEMENT.

The production of nearly 40,000,000 barrels of petroleum in Mexico in 1916 represents a gain of 21 per cent over the output in 1915 and establishes a new record for production of oil in that country that indicates the growing ability of Mexico to supply the world's needs in the matter of petroleum fuel. The most significant fact in connection with these statistics is that they represent merely the capacity of existing facilities for marketing Mexican oil and utterly fail to indicate the enormous potential capacity of the Mexican fields. Conservative estimates, based on the capacity of wells already drilled and closed in, place the potential production of the Mexican fields in excess of 725,000 barrels a day or roughly 260,000,000 barrels a year, a quantity only 13 per cent below the maximum annual output attained in 1916 from all fields in the United States.

The establishment of a stable government in Mexico and its adoption of a liberal policy toward the petroleum industry of the country would go far toward placing this country in the lead among the oil-producing countries of the world.

DEVELOPMENT.

The most notable completion of the year in Mexico was that of well No. 4 of the Huasteca Petroleum Co., in the Cerro Azul (Blue Mountain) pool. Although drilled to within a few feet of the productive formation, the Tamasopa limestone, in 1915, the well was not drilled in until 1916. The circumstances surrounding the completion of this great well are described by White [1] as follows:

> The well came in on the morning of February 10, 1916, with an enormous flow of gas which threw the wire cable and tools out of the hole several hundred feet into the air, wrecking the derrick and stripping off the valve connections to the casing, thus permitting the oil, which began to appear on the morning of February 11, to gush unchecked through the full capacity of the 8-inch casing for a period of eight days before the immense stream of oil, which rose to a height of 598 feet before the column began to break, could be brought under control.
>
> From the lay of the land it was fortunately possible not only to save a considerable portion of the oil which thus escaped but also to measure with considerable accuracy the amount of the flow. The well stands on the side of a basin from which there is only one outlet, the bed of a small stream which is dry at this time of the year, and as soon as the oil saver and fittings were torn off the company's capable organization began the construction of a number of earthen dams, seven in all, down the bed of this stream. It is estimated that 500,000 to 700,000 barrels of oil were saved in these temporary reservoirs. A temporary pipe line connecting with the company's main pipe lines, was laid to the lowest of these reservoirs, and pumps were installed to force the oil into the company's general pipe line to Tampico.
>
> As a means of calculating the flow of oil, Mr. Kunkel, the company's engineer, constructed a spillway about 5 meters in length from the lowest dam, No. 7, and checked the rate at which the oil flowed per second through this spillway, also measuring the width and depth of the flow. Precaution was taken that the level of the oil in the several reservoirs farther up the creek bed did not vary while the tests were being made, the oil being allowed to flow evenly through spillways of similar capacity in each dam. A considerable time was necessarily occupied in the construction of these reservoirs, and it was February 15 before the rate of flow was first gaged. From that date until February 19, five days inclusive, Mr. Kunkel gaged the flow as follows:

February 15	152,600 barrels daily.
February 16	190,209 barrels daily.
February 17	211,008 barrels daily.
February 18	221,186 barrels daily.
February 19	260,858 barrels daily.

[1] White, I. C., Third report on the properties of the Mexican Petroleum Co. (Ltd.), March, 1916.

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These results take no account of the vast quantity of oil that broke into fine spray and was carried by the wind in every direction over a radius of 2 miles, saturating the ground and all of the tropic jungle, so that I feel safe in estimating that the well was producing oil at a rate of but little if any less than 300,000 barrels daily when closed in on Saturday, February 19. The oil has a temperature of 122° F. and is of 21.4° Baumé gravity with no trace of moisture. When shut in, the well registered a pressure of 1,035 pounds per square inch.

The only other successful well completed in the southern fields in 1916 was No. 1 Tepetate, of the Tepetate Petroleum Co., which was credited with an initial production of 10,000 barrels. Six dry holes were reported in this field, 3 each by the Mexican Eagle Oil Co., on the Tanhuijo hacienda, and by the Penn Mex Fuel Co., on the Agua Nacida hacienda. Plans were under way at the end of 1916 for the construction of three pipe lines from producing properties in the Tepetate district to Port Lobos, on the Gulf coast.

In the northern fields 8 oil wells were completed in the Panuco district, the best of which, No. 1 Los Chotes, drilled by the R. E. Brooks interests, was credited with an initial capacity of 10,000 barrels. Three salt-water wells and 4 dry holes were also drilled in this field.

At Topila only 4 successful oil wells were brought in—all by the Corona Oil Co., on the Topila hacienda. Other completions included 2 dry holes and 3 salt-water wells.

In the Soto la Marina district in Tamaulipas, well No. 1 of the Corona Oil Co., on the ranch of San Jose de la Rusias, was barren.

At El Cerito efforts of the Mexican Fuel Oil Co. to develop production on the Cerito ranch resulted in the completion of 1 dry hole and of 1 oil well of small capacity.

At Lomas y Llanos, about 9 miles north of Panuco, the Giralda Co. obtained a 200-barrel oil well in a wildcat test on lot 5 in the hacienda of Ysleta.

At Tampico work was begun in 1916 by the Pierce Oil Corporation on the construction of an asphalt plant, and by the Interocean Oil Co., the Producers Terminal Co., and the Freeport & Mexican Fuel Oil Co. on wharfage and terminal facilities.

PRODUCTION.

The following figures are compiled from the best information available:

Petroleum produced in Mexico, 1907–1916, in barrels.

1907	1,717,690	1911	14,051,643	1914	21,188,427
1908	3,481,410	1912	16,558,215	1915	32,910,508
1909	2,488,742	1913	25,902,439	1916	39,817,402
1910	3,332,807				

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IMPORTS.

Petroleum and petroleum products imported into Mexico from the United States, years ending June 30, 1913, 1914, 1915, and 1916.

	1913		1914		1915		1916	
	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.
Crude	16,138,930	$590,098	14,900,388	$532,780	5,707,481	$216,656	12,050,278	$422,523
Naphtha	67,419	8,210	45,446	4,112	81,615	7,702	181,145	23,161
Gasoline	101,390	18,977	267,744	48,055	475,840	63,521	955,795	184,904
Illuminating	1,225,289	95,668	971,355	153,106	1,763,624	198,816	1,357,976	162,661
Lubricating	889,577	211,729	791,556	186,134	797,894	182,201	681,388	163,825
Gas oil and fuel oil	464	60	1,447,858	39,715	586,139	14,621	7,311,221	198,895
Residuum	15,108	646	27,384	2,495	8,179	409	38,820	2,263
	18,438,177	925,388	18,451,731	966,399	9,420,772	683,926	22,576,623	1,158,232

Mineral oils imported into Mexico from the United States, years ending June 30, 1907–1916.

Year.	Crude.		Refined, including residuum.		Total.	
	Quantity (gallons).	Value.	Quantity (gallons).	Value.	Quantity (gallons).	Value.
1907	19,992,434	$1,037,226	3,906,472	$511,990	23,898,906	$1,549,216
1908	17,523,440	901,115	1,839,803	320,235	19,363,243	1,221,350
1909	27,554,581	1,184,398	1,979,098	306,579	29,533,674	1,490,977
1910	41,202,786	1,428,632	2,333,558	357,258	43,536,344	1,785,890
1911	24,396,337	814,298	2,995,876	349,787	27,294,213	1,164,085
1912	22,752,588	884,320	1,659,566	259,234	24,412,154	1,143,554
1913	16,138,930	590,098	2,299,247	335,290	18,438,177	925,388
1914	14,900,388	532,780	3,551,343	433,619	18,451,731	966,399
1915	5,707,481	216,656	3,713,291	467,270	9,420,772	683,926
1916	12,050,278	422,523	10,526,345	735,709	22,576,623	1,158,232

WEST INDIES.

TRINIDAD.

Development of the petroleum resources of Trinidad proceeded steadily in 1916 and, although the British policy of refraining to publish statistics of mineral production until after the war prevents an accurate determination of the petroleum output of this island, it is believed that the output in 1916 was approximately 1,000,000 barrels.

Betterments installed by the Trinidad Leaseholds (Ltd.) during 1916 include a 6-inch pipe line 26 miles long from the Forest Reserve property of that company to the shipping point La Carriere, three storage tanks of 55,000 barrels capacity each at the latter point, and a topping plant at Point a Pierre.

Of considerable importance in the future development of the oil fields of Trinidad was the amalgamation in January, 1917, of the Trinidad Central Oilfields (Ltd.), the Ortoire Syndicate (Ltd.), the Oil Concessions of Mayaro (Ltd.), and the Cruse Syndicate (Ltd.). Under the new name of the Trinidad Central Oilfields (Ltd.), this company controls properties covering an area of 74,500 acres in the districts of Mayaro, La Brea, Guapo, and South Naparima, Island of Trinidad, on which 25 wells have been drilled, 19 of which are pro-

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ducing. The properties include also storage facilities for 30,000 barrels of oil, and a deep-sea loading line for conveying oil to steamers at Claxton Bay, on the Gulf of Paria, and a pipe line, under construction, from Tabaquite to Claxton Bay, a distance of 18 miles.

Petroleum produced in Trinidad, 1908–1916, in barrels.

1908	169	1911	285,307	1914	643,533
1909	57,143	1912	436,805	1915 (estimated)	750,000
1910	142,857	1913	503,616	1916 (estimated)	1,000,000

CUBA.

The persistent search for petroleum in Cuba was continued in 1916 in the vicinity of Havana without notable success.

HAITI.

Under a Government concession granted in 1916, the Haiti-American Corporation is reported [1] to have secured for its subsidiary, the Haiti Oil & Refining Co., absolute control of the oil industry in Haiti, including the sole right to operate refineries on the island and to import crude oil free of duty for use in its plants. The company, it is said, will market its products in Haiti through the West India Oil Co., a subsidiary of the Standard Oil Co. of New Jersey.

CENTRAL AMERICA.

COSTA RICA.

Interest in the possibilities of petroleum development in Costa Rica was increased in 1916 by the formation in the United States of the Costa Rica Oil Corporation, financed by the Sinclair interests, to determine the value of the concession referred to in this report for 1915 as having been granted to Leo J. Grenlich, of Oklahoma, for the development of prospective oil fields in the Provinces of Limon, Guanacaste, and Puntarenas. Operations during 1916 were restricted chiefly to geologic investigations in the Provinces covered by the concession. Late in the year, however, test wells were started near Uscari, Limon, on Amei River, in a locality where seepages of oil were numerous. To the end of 1916 the value of the oil showings in this locality had not been determined.

Late in 1916 the Northern Railway Co., operating lines from Port Limon to San Jose, in the Province of Limon, decided to adopt Mexican oil as fuel on all its locomotives. Provision for unloading tank steamers and for the storage of 110,000 barrels of oil was made at Port Limon, and storage tanks of smaller capacities were installed at Zeut, Siquirres, Guacimo, Peralta, Juan Vinas, Cartago, and San Jose.

PANAMA.

Early in 1917 the National Assembly at Panama authorized the Executive to make concessions of unoccupied territory to persons exploring for oil or gas for terms not to exceed three years and to make contracts for the working of oil lands for periods of 20 years,

[1] Haiti's oil industry to be developed: Min. and Eng. World, issue of Dec. 30, 1916.

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subject to renewal or extension for a second period of equal length. The royalty prescribed is 10 per cent of the net profits or 50 per cent of the gross receipts for oil or gas marketed.

SOUTH AMERICA.

COLOMBIA.

Since the opening of the Panama Canal, interest in the development of oil fields in Colombia has been steadily increasing. Within the last few years American, English, and Canadian interests have sought concessions of prospective oil territory in that country. It is estimated that $750,000 has been spent in recent years in unsuccessful efforts to find oil in commercial quantities in the Sinn region. This failure has not, however, discouraged foreign investors, and in 1916 the Tropical Oil Co., composed of Pittsburgh capitalists, was organized for the development of some 2,500,000 acres in the Robert de Mares concession along Magdalena River, in the Province of Bolivar. A number of wells were started before the end of 1916. The Carib Syndicate, another American corporation, is also reported to have acquired by purchase a large tract of land in the Magdalena Valley, not far from the holdings of the Tropical Oil Co., and to have undertaken a thorough test of the area, after careful geologic investigation.

VENEZUELA.

The status of the petroleum industry in Venezuela in 1916 is described as follows in a report by American Minister Preston McGoodwin, at Caracas:[1]

There are in Venezuela six petroleum companies engaged in development work on an extensive scale—the Caribbean Petroleum Co., Colon Development Co., Venezuelan Oil Concessions (Ltd.), Venezuela-Falcon Oil Syndicate (Ltd.), Bermudez Co., and the Pauji Concession. The first-mentioned of these—the Caribbean Petroleum Co.—acquired what was known as the Tregelles concession from the General Asphalt Co., and during 1912 and 1913 employed a force of 35 experienced geologists, assisted by a great number of Venezuelan civil engineers, who covered nearly every foot of territory included in the concession. At the end of two years the company had staked out and definitely selected 1,028 areas of 500 hectares (1,235 acres) each, in which it intended, within the time allowed, to drill for oil.

For its preliminary work the company selected two sections for drilling, one on each side of Lake Maracaibo, State of Zulia, in the extreme northwestern part of Venezuela. One of these sections is 16 miles east of the lake, where material has to be transported through swamps over a road built by the company. When the road was completed and properly screened houses had been erected for the employees, drilling equipment for three wells was immediately shipped in and drilling commenced in January, 1914. On this area the company has drilled six wells, from 600 to 1,700 feet in depth, in all of which oil has been found. Enough work has been done to prove conclusively that this is a commercial field. Most of these wells are capped.

Development work of Caribbean Co.—The company has erected three 55,000-barrel steel tanks, has laid a pipe line to the shore of Lake Maracaibo, and has built a refinery at the terminal of its pipe line at a place called San Lorenzo. Every grade of oil except lubricants will be refined at this point. Pumps and pipe lines have been installed for loading tank steamers or barges for the shipment of the oil from Venezuela. It is planned to have the refinery, pumping station, and pipe line completed in time for the company to make its first shipments in December, 1916.

The field selected by this company on the western side of Lake Maracaibo is about 50 miles from the shore of the lake, and a road had to be built to it for the transportation of material through a flat but heavily wooded country. As on the east side of the lake, the company delivered to this site equipment sufficient for drilling three wells.

[1] Commerce Reports, Oct. 7, 1916.

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Two wells were sunk to a level of about 1,000 feet and abandoned prior to April, 1915. In June, 1916, work was started on four additional wells in this section for testing purposes, the deepest of which is now about 800 feet.

The same company is developing areas in other sections, as it is required to do under the terms of its contract with the Government of Venezuela. Although the section on the east side of Lake Maracaibo undoubtedly contains oil in quantities sufficient for commercial development, no information is obtainable upon which to base an estimate of probable future production.

Colon Development Co.—Under what was known as the Andrés Jorge Vigas concession, granted January 3, 1907, for oil rights in the district of Colon, State of Zulia, the Colon Development Co., an English corporation, commenced drilling operations early in 1914. This company encountered difficulty in its geological exploration work, owing to roving bands of Motilones Indians. It was necessary to employ from 60 to 100 armed guards with the exploring parties, and a force of 50 to 60 guards has been kept at the drilling camps.

Development was started by this company about 100 miles from the nearest settlement, and, although there are rivers for transporting material, it was necessary to expend immense sums in delivering equipment. The first drill was started the latter part of 1914, and after having experienced great difficulties with drillers and laborers, the first well was abandoned at a depth of 700 feet. The company has just succeeded in drilling its second well on the Rio Oro. The depth attained is somewhat over 1,000 feet, and the oil is of light gravity. The capacity of this well is said to be approximately 200 barrels a day. However, means of transportation must be provided, and the company is now engaged in building roads for that purpose; also in drilling another well on the Rio Tarra, now said to have reached a depth of about 500 feet.

The best information to be had from persons who are familiar with the territory occupied by the Colon enterprise is to the effect that the company will produce oil in commercial quantities.

Venezuelan Oil Concessions (Ltd.).—On February 28, 1907, a contract was granted to one Antonio Aranguren for the development of asphalt in the districts of Bolivar and Maracaibo of the State of Zulia, and on June 18, 1912, a decree was issued by the Government of Venezuela, bestowing upon the concessionaire the right to exploit petroleum. There has been some question raised as to the legality of this latter decree, but, notwithstanding protests made by other oil-producing companies, the decree has been allowed to stand. In the latter part of 1913 it was transferred, after preliminary geological investigation, to the Venezuelan Oil Concessions (Ltd.), an English corporation.

Four drillers and an office staff and field superintendent were sent out from London late in 1913 by this company. Two wells were started immediately, one at a point on the shores of Lake Maracaibo called Santa Rita, and the other in the swamp just south of Santa Rosa, also located on the shores of the lake. Drilling in the Santa Rita well was carried to a depth of 1,600 feet without any trace of oil having been encountered. At Santa Rosa an oil sand of good promise was encountered at 800 feet, and at 1,500 feet another sand was found which produced oil of about 20° B. Undoubtedly upon striking this last sand a great quantity of oil was produced, but ten days after the strike the production was not more than 10 barrels a day. Apparently no attempt was made to pump this well, and it seems to have been abandoned.

The company encountered very great obstacles because of the general unhealthful conditions under which the men were compelled to work and the impossibility of keeping them protected from the very dangerous malarial mosquito found in those localities. Also, the company seemed to realize, about the middle of 1914, that the system used in drilling was not suitable to the conditions and placed an order for drilling equipment in the United States. It was planned to start work with this new machinery immediately, but operations were seriously hampered by the outbreak of the European war.

Although work has been carried on continuously it has been done with a very limited force, and no very satisfactory results have been obtained. To date the company has succeeded in drilling seven wells, varying in depth from 600 to 1,800 feet and scattered over a considerable area. It has been reported that oil was found in five of the seven wells and that at least two of them give promise of good production.

Venezuela-Falcon Oil Syndicate (Ltd.).—On July 22, 1907, there was granted what is known in Venezuela as the Bernabé Planas concession for the development of oil in the district of Buchivacoa in the State of Falcon. After having been offered for sale for a number of years an option was given, in 1913, to an English company called the Venezuela-Falcon Oil Syndicate (Ltd.). After preliminary investigation lasting about a year and a half, the company finally agreed to start development work, but it appears that the equipment has not yet been delivered.

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The Bermudez Co.—On July 14, 1910, the General Asphalt Co., which owned the large asphalt deposit known as Bermudez Lake, situated in the extreme northeastern part of Venezuela at a place called Guanoco, obtained a concession for the oil rights in the vicinity of the lake, also on the island of Pedernales and the peninsula of Paria. This concession, obtained by R. M. Valladares, was transferred to a subsidiary of the asphalt company called the Bermudez Co. Very soon after acquiring the right the Bermudez Co. sent a force of 10 geologists over its concession and finally selected 19 areas of 500 hectares each in the vicinity of the asphalt lake, 6 areas on the peninsula of Paria, and 4 areas on the island of Pedernales. The terms of the concession of the Bermudez Co. called for almost immediate exploitation of all areas selected. By June, 1913, wells were being drilled on all of the 29 areas. On the 6 areas of the peninsula of Paria wells were sunk deep enough to demonstrate the impossibility of producing oil in commercial quantities, and all of them were promptly abandoned.

At Pedernales the company drilled seven wells ranging in depth from 200 to 1,000 feet, occasionally finding traces of oil but not in sufficient quantities. In this region the company encountered great difficulties because of heaving sands, soft mud, and gas pressure, all of which made it necessary for the company to adopt several methods of drilling.

In the Guanoco areas wells have been sunk in varying depths from 200 to 4,200 feet. In some of them a heavy oil, almost an asphalt, has been found, and invariably in fair quantities, but it is too heavy to pump. Two additional wells have been started in this region quite recently, but no commercial results have been obtained. The company has done considerable geological work to locate a proper place to drill where it could reach oil, still believed to exist in large quantities in that region.

The operations of this company have been exceedingly difficult because nearly all the wells in the three regions described are located in swamps, and it has been necessary to lay portable tracks on trestles to transport drilling material. Although the general camp of the company was located at the same place as the headquarters of the General Asphalt Co., where several hundred employees are maintained constantly, yet the field camps have been in very unhealthful places and there has been considerable sickness among the employees.

Pauji concession—No other work now in progress.—On January 16, 1909, a petroleum concession was granted to Joaquín Briceño on 3 hectares (7.4 acres) of land adjoining a place known as Pauji, 30 miles east of Lake Maracaibo. The right was secured doubtless because of the abundant evidence of asphalt seepages, which are very numerous in that locality. A company was formed recently in the city of Maracaibo with a large nominal capital but with only about $50,000 for actual work. An American has been investigating the property, and it is reported in Caracas that drilling machinery will shortly arrive. Stockholders are confident that development work will be pushed rapidly.

In addition to the properties of the six companies above enumerated, there are not more than three or four ancient and modern concessions in existence, and no other development is now known to be in progress.

Progress on the oil refinery of the Curaçaosche Petroleum Maatschappij at Willemstad, on Curaçao, one of the Leeward Islands belonging to Holland off the north coast of Venezuela, was impeded by scarcity of labor and by delays in the delivery of structural materials and machinery contracted for in the United States. As reported in the report for 1915 of this series, the company building this refinery is one of the entities of the Royal Dutch-Shell group, that acquired in 1915 control of the concession of the Venezuela Oil Concessions (Ltd.), comprising about 3,000 square miles in the districts of Maracaibo and Bolivar, State of Zulia.

GUIANA.

That efforts are being made to prove or disprove the possibilities of the occurrence of oil in British Guiana is shown in a report dated August 24, 1916, by Consul George E. Chamberlin [1] at Georgetown, which states:

[1] Commerce Reports, Oct. 20, 1916.

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Three exploration licenses under the mining (mineral oil) regulations for tracts in the northwestern district were in existence on December 31, 1915. The holder of one of these exploration areas applied for a prospecting license, and at the close of the year arrangements had been made to import well-boring apparatus, which arrived in the colony early in 1916 and was shortly afterward transported to the locality where it is expected boring operations will be commenced. The holders of the two other tracts did nothing in the way of exploration, but it is understood that they are jointly interested in the boring plant mentioned.

BOLIVIA.

The Sociedad petrolífera de Bolivia, a Chilean syndicate, capitalized at $10,000,000 to exploit an area of 1,345,150 acres of prospective oil land in the Province of Santa Cruz, Bolivia, is apparently going forward vigorously with its development projects.

During 1916 a commission of engineers was sent to make a thorough examination of the property, and is reported to have submitted an encouraging report. According to provisional plans the oil will be conveyed by pipe lines from the lowlands about Santa Cruz to the Andean highlands to the west and from there distributed by pipe line or by rail to the Bolivian and Chilean mining centers.

ECUADOR.

Evidences of the occurrence of petroleum in commercial quantities are said to exist near Santa Rosa, in the Province of El Oro, and at various points in the Province of Guayas, in a belt extending southeastward from Puntilla near the port of Santa Helena to San Vicente, a point about 90 miles southwest of Guayaquil. These areas are owned or controlled by local syndicates, but the proprietors are endeavoring to interest United States capitalists in their development.

PERU.

GENERAL STATEMENT.

More oil was produced in Peru in 1916 than in any other year in the history of the local petroleum industry, which dates from 1896. The quantity produced in 1916 was 340,086 metric tons, equivalent to 2,550,645 United States barrels of 42 gallons each, and was nearly 3 per cent greater than the output in 1915. The principal gain was in the Negritos and Lagunitos fields, which are operated by the International Petroleum Co. of Canada, and supply crude oil to that company's refineries at Talara, Peru, and near Vancouver, British Columbia.

A moderate gain in output was also credited to the Zorritos field, in the Province of Tumbes. This field is controlled by Fausto G. Piaggio, of Callao, and its output, after treatment in a local refinery, finds a ready market in the cities and towns along the west coast of South America.

Production in the Lobitos district, controlled by the Lobitos Oil Fields (Ltd.), of London, decreased about 2 per cent compared with 1915.

At the end of 1916 there were 659 producing oil wells in the Negritos and Lagunitos districts and 131 in the Lobitos district.

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Under date of July 15, 1916, Consul G. H. Pickerell, at Para, Brazil, reported [a] the receipt of information to the effect that evidences of petroleum had been found in Peru at a point along Huallaga River, about two days' journey from Yurimaguas. Samples of oil from this locality were reported to be of such good quality as to stimulate scientific investigation of the possibilities of the new area.

PRODUCTION.

Petroleum produced in Peru, 1907–1916, in barrels of 42 gallons each.

Year.	Lobitos.	Negritos.	Zorritos.	Lake Titicaca (Huancane).	Lagunitos.	Total.	
						Barrels.	Metric tons. [b]
1907	[c] 279,000	396,750	65,476	15,000	.....	756,226	100,830
1908	319,898	543,750	71,429	[d] 76,103	.....	1,011,180	134,824
1909	429,195	740,070	70,750	[d] 76,103	.....	1,316,118	175,482
1910	400,080	773,025	107,000	[d] 50,000	.....	1,330,105	177,347
1911	391,290	882,698	64,286	[d] 30,000	.....	1,368,274	182,436
1912	587,048	1,071,000	78,095	[d] 15,000	.....	1,751,143	233,486
1913	557,355	1,136,490	83,343	[d] 10,000	346,073	2,133,261	284,434
1914	504,743	1,032,210	88,136	[d] 10,000	282,713	1,917,802	255,707
1915	664,972	1,355,925	72,736	[d] 1,000	392,618	2,487,251	331,633
1916	654,060	[e] 1,822,733	73,852	.....	(e)	2,550,645	340,086

[a] Commerce Reports, Aug. 7, 1916.
[b] One metric ton=7.5 barrels.
[c] Includes Lagunitos.
[d] Estimated.
[e] Included in Negritos.

Petroleum produced, shipped, and in stock and number of producing wells in Lobitos oil field, Peru, 1907–1916.

Year.	Production.		Shipments.	Stock Dec. 31.	Producing wells Jan. 1.
	Metric tons.	Barrels.	Metric tons.	Metric tons.	
1907	[a] 37,200	279,000	25,821	4,816	.....
1908	42,653	319,898	36,131	8,860	26
1909	57,226	429,195	54,289	11,797	62
1910	53,344	400,080	.....	.....	.....
1911	52,172	391,290	.....	.....	92
1912	78,273	587,048	.....	.....	105
1913	74,314	557,355	.....	.....	110
1914	67,299	504,743	.....	.....	.....
1915	88,613	664,972	.....	.....	119
1916	88,208	654,060	.....	.....	131

[a] Estimated.

Petroleum produced in Negritos oil field, Peru, 1907–1916.

Year.	Metric tons.	Barrels.	Year.	Metric tons.	Barrels.
1907	52,900	396,750	1912	142,800	1,071,000
1908	72,500	543,750	1913	151,532	1,136,490
1909	98,676	740,070	1914	137,628	1,032,210
1910	103,070	773,025	1915	180,790	1,355,925
1911	117,693	882,698	1916	[a] 243,031	1,822,733

[a] Includes Lagunitos field.

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Petroleum produced in Zorritos oil field, Peru, 1907–1916, in gallons.

Year.	Crude.	Refined.a	Gasoline.	Benzine.	Year.	Crude.	Refined.a	Gasoline.	Benzine.
1907	2,750,000	420,000	101,000	20,000	1912	3,280,000	476,620	226,440	.....
1908	3,000,000	500,000	150,000	30,000	1913	3,500,424	565,320	324,000	.....
1909	2,971,510	469,610	96,520	.....	1914	3,701,718	482,850	277,440	.....
1910	4,494,000	.....	.....	.....	1915	3,054,900	461,510	362,230	.....
1911	2,700,000	650,000	.....	200,000	1916	3,101,790	468,790	396,720	.....

a Kerosene.

CHILE.

Commerce Reports, issue of October 10, 1916, says concerning new possibilities of oil development in Chile:

NEW OIL FIELDS IN CHILE.

Recent discoveries of oil in the Territory of Magellan have created much interest, for heretofore Chilean oil has been found only in the northern and central sections of that country. The National Association of Manufacturers (Sociedad de fomento fabril) in a recent bulletin states that geological experts from various parts of the world have made tests of the oil in Magellan and pronounce it equal in quality to that found in Argentina, and the extent of the deposits appears to rival that of the famous Comodoro Rivadavia fields.

Commenting on the prospective working on an extensive scale of the oil lands in Chile, the manufacturers' association presents the need of legislation to regulate the well drilling, with a view to preventing the inundation of the oil deposits by subterranean streams. The association also advocates legislation to restrict the owning and operating of oil wells to native Chileans or to foreigners settled in the country with Chilean families. The greater part of the oil lands in Magellan belongs to the Government, and the association recommends that the Government retain a royalty of 10 per cent on all the oil produced from the lands it sells to private producers. Such a royalty is frequently stipulated by individual owners, and it is urged that the right to a percentage should be legalized and extended to all proprietors of oil fields.

ARGENTINA.

As a result of a detailed study of the producing and prospective oil fields of Argentina, the Argentine Bureau of Mines and Geology has been able to determine with considerable precision the areas in which deposits of petroleum exist.

According to a report[1] of these studies four distinct and well-defined petroleum districts are indicated, exclusive of certain other areas in which doubtful evidences of oil are known. One of these districts, of restricted area, is in the southern extremity of the mountainous area in the Province of Mendoza; another includes an extensive area of asphalt showings in the northern part of Mendoza and the southern part of Neuquen; the third and best-known comprises the Patagonian coast contiguous to Comodoro Rivadavia; and the fourth occupies a roughly triangular area, with sides approximately 100 miles in length, in the lower Andes along the Bolivian frontier in the provinces of Salta and Jujuy.

Oil from the first district is reported to yield on distillation 4 per cent of light oil (naphtha and gasoline), 23 per cent of illuminating oil, and 73 per cent of heavy oil from which as much as 35 per cent of paraffin has been extracted. This area was the first to be exploited, but between 1886, when it was first surveyed, and 1891, when the field

[1] Native oil may solve Argentine fuel problem: Commerce Reports, June 2, 1917.

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was abandoned, only about 8,000 tons of oil were produced. Subsequently three other wells were drilled, and about 1911 another revival of activity resulted in the drilling of two additional wells without notable success, though oil was found in one of the later wells at a depth of 2,150 feet. The recent investigation has shown that this field, though "spotted," is worthy of further exploitation.

The results of the bureau's investigation, though restricted to small areas, indicate the general presence of favorable geologic structures in the southern part of the Republic, both in Mendoza and in Neuquen, which are believed worthy of thorough tests with the drill.

This report [1] states further that

The existence of primary petroleum deposits in the vicinity of Cerro Lotena is also considered probable, although the works hitherto carried out there are of small importance. A more serious attempt in this zone was that made in the Department of San Rafael, Province of Mendoza, but the results were only mediocre. On the northwestern slope of one of the hills in this district a boring revealed the existence of petroleum of a high specific gravity at a depth of 220 meters. As regards the other petroliferous manifestations of the southern part of Mendoza and Neuquen, these have so far induced only a few persons to petition for exploring concessions, but no work worthy of mention has been carried out.

The general situation of the petroleum deposits in the Patagonian region reveals very different characteristics. Their existence was unknown until December 13, 1907, when petroleum was met with in the course of boring for drinking water. From that time onward careful surveys of the subsoil of this region have been made in the vicinity of Comodoro Rivadavia, within the zone of 5,000 hectares (12,355 acres) which the Government ordered to be reserved. Borings have been effected methodically, and it can be said that in every case where a sufficient depth has been attained, that is to say 500 meters below sea level, petroleum has been met with, and it has been proved that there exists here one of the most important petroliferous areas of the world. The quality of this oil is exceptionally good. It is a heavy petroleum and contains a small proportion of light oil. Its heating power is excellent.

By means of destructive distillation it has been proved that from Comodoro Rivadavia petroleum can be extracted 5 per cent of benzine, 16.27 per cent of illuminating oils, and 67 per cent of oil, with the advantage that it can be used as fuel in the state in which it leaves the wells, either by the employment of special burners, or directly in internal-combustion motors. It is not necessary to emphasize the fact that the exploitation of these oil fields constitutes an enormous national wealth, and that in the present circumstances if the output were sufficient for the demands of consumption it would be one of the principal factors in the development of our industries.

In the zone reserved by the Government new surveys are being carried out as the working of the existing wells becomes intensified.

It is considered that the exploitation of this zone ought to be still further intensified, applying to it the most modern method and increasing the number of tank steamers required to carry the oil in large quantities to the consuming centers, where it meets with a ready market.

The northern petroliferous zone is considered to be an isolated one, having no geological vinculations with the others existing in the country, but presenting all the characteristics common to the presence of this mineral. No petroleum working, properly speaking, has taken place yet in this zone, although certain attempts have been made at the foot of the Sierra de Zapla, near a lake of the Province of Jujuy, and in one of the "quebradas" of the Province of Salta. In the first two mentioned districts the oil gushes from the second calcareous level and in the third from the higher sand stratum. The few borings effected in these three districts have so far given no practical results whatever.

The other points of this zone which present petroleum manifestation, but where no work has yet been done, are: Loma de Ipaguazu, Aguas Calientes, Quebrada de Iquira, Zanga Honda, Sierra del Alto, Rio Chico, Agua Blanca, Vado Hondo, and Rio Colorado. Analyses of samples of petroleum taken from the surface in this zone indicate that the product is very liquid, yellow or orange yellow in color, and rich in illuminating oils; in other cases petroleum is somewhat more dense, grayish red in color, with green florescence, and containing a high proportion of lubricating oils. In the first case the density varies between 0.75 and 0.85, while in the second it is 0.9.

[1] Op. cit.

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Petroleum produced in Argentina, 1907–1916.

Year.	Metric tons.	United States barrels.	Year.	Metric tons.	United States barrels.
1907	13	101	1912	6,850	47,007
1908	1,680	11,472	1913	19,050	130,618
1909	2,700	18,431	1914	40,530	275,500
1910	3,050	20,753	1915	75,900	516,120
1911	1,920	13,119	1916	116,000	870,000

EURASIA.

RUSSIA.

GENERAL STATEMENT.

Such statistics as are available concerning the petroleum industry in Russia in 1916 indicate a gain of about 6 per cent in production compared with 1915. The total yield in 1916, which is estimated to have amounted to 606,433,246 poods (72,801,110 United States barrels of 42 gallons each) establishes a new record for production of petroleum in Russia, which is especially gratifying in view of the serious difficulties in the matter of labor troubles, scarcity of requisites for drilling, and restricted markets that have been encountered since thebeginning of the war.

Credit for the increase in 1916 is divided between the Baku district, on Apsheron Peninsula, and the Grosny district, on the north flank of the Caucasus, production in the other districts being less, notably so at Maikop, than in 1915.

The gain of 8 per cent credited to the Baku district was due in part to drilling on lands reclaimed at Government expense from Bibi-Eibat Bay and added to the Bibi-Eibat field, but principally to the remarkable success of drilling in the Surakany field during the last half of 1916.

The gain of 16 per cent at Grosny came almost wholly from wells drilled in the new area opened by the Government for exploitation in 1915. In the old area production was less in 1916 than in 1915 because of a decrease in drilling.

The decided slump in production at Maikop is accounted for in part by the lessened activity in drilling but principally by the fact that the prolific gusher well brought in by the Anglo-Maikop Corporation (Ltd.) on plat 457 in the Neftianaya field in March, 1915, ceased to flow in January, 1916.

The decreased output of the other districts in 1916 is due chiefly to the scarcity of labor and of drilling materials. By establishing on January 14, 1916, a maximum price of 45 kopecks per pood (about $1.93 a barrel), plus ordinary pipeage and storage charges, for Baku oil, with appropriate variations for the product of other districts, the Russian Government inaugurated a policy of price fixing in the petroleum industry that remained in force throughout the year despite repeated appeals from the harassed producers, whose costs of operation had increased enormously since the beginning of the war.

The fact that the official price, which remained unchanged during 1916, was decidedly less than the increased demand for oil in the

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interior of Russia would normally warrant caused considerable resentment on the part of the producers and is said to have resulted in various subterfuges that worked much injustice to the law-abiding producer and to the producer whose oil was under contract at the fixation price. After numerous appeals relief was granted in the early part of 1917; and the price of Baku oil advanced in January to 55 kopecks per pood (about $2.35 a barrel), in February to 61 kopecks per pood (about $2.60 a barrel), and the 1st of April to 65 kopecks per pood (about $2.80 a barrel).

PRODUCTION.

Petroleum produced in Russia, 1906–1916.

Year.	Baku.		Grosny.		Maikop.	
	Poods.[a]	Barrels of 42 gallons.	Poods.	Barrels of 42 gallons.	Poods.	Barrels of 42 gallons.
1906	447,520,000	53,723,899	38,373,603	4,606,675	.....	.....
1907	476,002,000	57,143,097	39,214,612	4,707,637	.....	.....
1908	465,954,221	55,936,880	52,058,895	6,249,567	.....	.....
1909	492,500,000	59,123,650	57,033,015	6,846,700	.....	.....
1910	508,456,121	61,039,149	74,048,358	8,889,359	1,304,800	156,640
1911	454,206,853	54,526,633	75,189,591	9,026,361	7,933,936	952,453
1912	473,200,000	56,805,723	65,400,000	7,851,140	9,200,000	1,104,442
1913	404,538,000	48,563,985	73,659,265	8,842,649	4,802,926	576,582
1914	412,246,851	49,489,418	98,445,187	11,818,150	3,956,906	475,019
1915	431,139,305	51,757,419	88,159,052	10,583,320	7,582,000	910,204
1916	464,902,000	55,810,564	102,731,246	12,332,683	2,000,000	240,096

Year.	Emba.		Other.		Total.	
	Poods.	Barrels of 42 gallons.	Poods.	Barrels of 42 gallons.	Poods.	Barrels of 42 gallons.
1906	.....	.....	[b] 4,721,000	566,747	490,614,603	58,897,311
1907	.....	.....	.....	.....	515,216,612	61,850,734
1908	.....	.....	.....	.....	518,013,116	62,186,447
1909	.....	.....	.....	.....	549,533,015	65,970,350
1910	.....	.....	[c] 2,094,381	251,426	585,903,660	70,336,574
1911	.....	.....	[d] 13,979,771	1,678,244	551,310,151	66,183,691
1912	.....	.....	[e] 18,800,000	2,256,903	566,600,000	68,019,208
1913	7,182,000	862,184	[f] 33,228,000	3,988,956	523,410,191	62,834,356
1914	16,675,000	2,001,801	26,957,000	3,236,134	558,280,944	67,020,522
1915	16,632,000	1,996,639	27,493,000	3,300,480	571,005,357	68,548,062
1916	15,200,000	1,824,730	21,600,000	2,593,037	606,433,246	72,801,110

[a] 61.05 poods=1 metric ton crude; 8.33 poods crude=1 United States barrel of 42 gallons; 8 poods illuminating oil=1 United States barrel of 42 gallons; 8.18 poods lubricating oil=1 United States barrel of 42 gallons; 9 poods residuum=1 United States barrel of 42 gallons; 7.50 poods naphtha=1 United States barrel of 42 gallons; 8.3775 poods other products=1 United States barrel of 42 gallons, estimated; 1 pood=36.112 pounds; 1 kopeck=0.515 cents.

[b] Produced in Berekei and Tchimion oil fields.

[c] Includes as follows: Sviatoi, 1,392,306 poods; Ferghana, 610,500 poods; and Taman, 91,575 poods.

[d] Includes as follows: Sviatoi, 2,515,363 poods; Tcheleken, 10,205,740 poods; and Ferghana, 610,500 poods; other districts, 648,158 poods.

[e] Includes as follows: Sviatoi, 3,300,000 poods; Tcheleken, 13,300,000 poods; and Ferghana, 2,200,000 poods.

[f] Includes as follows: Sviatoi, 4,733,000 poods; Balakhani, 13,860,000 poods; Berekei, 6,000,000 poods; Ferghana, 1,406,000 poods; and Tcheleken, 7,229,000 poods.

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Petroleum produced from pumping and flowing wells in Russia in 1915 and 1916.

District.	1915				1916 [a]			
	Pumping (barrels).	Flowing (barrels).	Total.		Pumping (barrels).	Flowing (barrels).	Total.	
			Barrels.	Poods.			Barrels.	Poods.
Apsheron Peninsula or Baku:								
Balakhani	8,010,928	6,003	8,016,931	66,781,039	.....	.....	10,204,082	85,000,000
Sabunchi	17,192,964	.....	17,192,964	143,217,390	.....	.....	12,004,802	100,000,000
Romani	6,405,817	.....	6,405,817	53,360,458	.....	.....	6,962,785	58,000,000
Bibi-Eibat	8,200,374	1,299,175	9,499,549	79,131,239	.....	.....	10,768,307	89,700,000
Binagadi	2,529,532	660,264	3,189,796	26,571,000	.....	.....	4,141,056	34,495,000
Surakany	4,970,730	2,313,565	7,284,295	60,678,179	.....	.....	11,729,532	97,707,000
Caught at canals at Baku	168,067	.....	168,067	1,400,000	.....	.....	.....	.....
	47,478,412	4,279,007	51,757,419	431,139,305	.....	.....	55,810,564	464,902,000
Grosny	10,369,507	213,813	10,583,320	88,159,052	.....	.....	12,332,683	102,731,246
Maikop	324,850	585,354	910,204	7,582,000	.....	.....	240,096	2,000,000
Emba	1,996,639	.....	1,996,639	16,632,000	.....	.....	1,824,730	15,200,000
Sviatoi	778,751	49,460	828,211	6,899,000	.....	.....	840,336	7,000,000
Ferghana	217,527	.....	217,527	1,812,000	.....	.....	240,096	2,000,000
Tcheleken	479,352	.....	479,352	3,993,000	.....	.....	360,144	3,000,000
Balakany (hand wells)	921,969	.....	921,969	7,680,000	1,152,461	.....	1,152,461	9,600,000
Schubany (hand wells)	850,060	.....	850,060	7,081,000				
Bereka	.....	3,361	3,361	28,000	.....	.....	.....	.....
Grand total	63,417,067	5,130,995	68,548,062	571,005,357	.....	.....	72,801,110	606,433,246

[a] Details not available.

Crude petroleum produced on the Apsheron Peninsula and petroleum products shipped from Baku, Russia, 1907–1916, in barrels.

Year.	Production.	Shipments from Baku.					
		Illuminating.	Lubricating.	Other products.	Residuum.	Crude oil.	Total.
1907	57,143,097	11,450,019	1,724,664	565,689	27,833,892	4,290,500	45,864,764
1908	55,936,880	10,682,750	1,754,034	105,163	23,989,778	5,398,200	41,929,925
1909	59,123,650	8,261,368	1,728,833	1,087,115	23,404,954	6,182,973	40,665,243
1910	61,039,149	9,978,406	1,892,046	1,381,921	24,414,210	6,207,278	43,873,861
1911	54,526,633	10,406,454	1,999,503	1,388,776	26,091,096	5,713,538	45,599,367
1912	56,806,723	10,639,896	2,372,605	1,875,209	21,961,469	6,054,324	42,903,693
1913	48,563,985	10,380,813	2,326,931	1,196,169	22,227,408	6,974,106	43,105,427
1914	49,489,418	8,511,556	1,331,818	656,094	19,438,241	6,883,805	36,821,514
1915	51,757,419	7,029,846	844,297	374,181	27,223,899	8,679,248	44,151,471
1916	55,810,564	7,973,360	924,365	134,619	30,173,928	7,594,952	46,801,224

Wells in the Baku oil fields, Russia, Dec. 31, 1915, and Aug. 31, 1916.[a]

Condition of wells.	Balakhani.		Sabunchi.		Romani.		Bibi-Eibat.		Total.	
	1915	1916	1915	1916	1915	1916	1915	1916	1915	1916
Completed	42	.....	59	.....	20	.....	17	.....	138	.....
Producing	1,055	1,063	1,339	1,314	284	285	297	316	2,975	2,978
Trial pumping	6	3	6	7	4	3	3	2	19	15
Being drilled	55	37	68	75	65	60	43	58	231	230
Being drilled deeper	19	37	29	68	8	45	19	42	75	192
Cleaning out and repairing	42	2	75	12	52	18	50	6	219	38
Standing idle	418	477	867	968	310	338	253	253	1,848	2,036
Rigs up, ready for drilling	58	63	63	59	14	13	14	11	149	146
New wells sunk during year	38	.....	65	.....	42	.....	14	.....	159	.....
Length of wells drilled, in feet	76,090	3,603	122,458	9,807	81,410	5,140	53,711	3,204	333,669	21,754

[a] Complete details for 1916 not available.

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Stocks of petroleum in Baku, Russia, Dec. 31, 1912–1916, in barrels.

	1912	1913	1914	1915	1916
At oil wells: Crude	952,676	1,068,427	1,099,851	972,389	(a)
At refineries:					
Crude	2,551,577	2,081,428	3,587,960	3,791,597	3,739,330
Illuminating	1,268,626	1,144,663	1,401,197	1,517,912	1,121,302
Lubricating	260,397	260,599	253,127	364,132	378,811
Residuals	3,396,775	2,817,656	4,625,735	4,125,300	4,087,352
Other products	443,643	374,909	446,274	358,150	376,798
	8,873,694	7,747,682	11,414,144	11,129,480	9,703,593

a Not available.

Well record in the Grosny oil field, Russia, 1912–1916.

Year.	Number of plots.		Total wells.	Producing Dec. 31.	Being bored or deepened Dec. 31.	Average depth of wells (feet).	Total length of wells drilled in the year (feet).
	Producing.	Being exploited.					
1912	.....	223	402	264	71	1,752	119,165
1913	83	280	554	352	116	1,798	201,867
1914	86	315	665	435	123	1,885	275,814
1915	.....	393	.....	.....	.....	.....	178,143
1916	.....	.....	.....	.....	.....	.....	151,732

Crude petroleum on hand in Grosny field Dec. 31, 1912, 245,583 barrels; Dec. 31, 1913, 533,133 barrels.

Petroleum shipped from Novorossisk, Russia, 1911–1915,[a] in metric tons.

Year.	Crude oil.	Illuminating.[b]	Benzine.	Residuals.	Total.
1911	18,690	62,044	65,520	76,092	222,346
1912	.....	90,444	123,098	24,817	238,359
1913	.....	69,216	120,000	20,973	210,189
1914	228	15,966	.....	16,087	32,281
1915	2,758	1,212	.....	4,088	8,058

a Figures for 1916 not available. b Refined.

Stocks of petroleum at Novorossisk, Russia, Dec. 31, 1912, 1913 and 1915.[a]

	1912		1913		1915	
	Poods.	Barrels.	Poods.	Barrels.	Poods.	Barrels.
Crude	72,000	8,643	100,600	12,077	.....	.....
Illuminating oils	443,400	55,425	738,100	92,263	584,300	70,144
Astatki	230,000	25,555	839,000	93,222	23,900	2,869
Other products	1,073,900	127,845	1,736,500	207,281	52,700	6,327
	1,819,300	217,468	3,414,200	404,843	660,900	79,340

a Figures for 1914 and 1916 not available.

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Petroleum shipped from Batum, Russia, 1911–1915.[a]

Year.	Refined, petroleum.	Lubricating.	Residuals.	Total.
	Metric tons.	*Metric tons.*	*Metric tons.*	*Metric tons.*
1911	353,518	171,725	57,282	582,525
1912	327,338	188,894	53,300	569,532
1913	454,165	183,180	62,594	699,939
1914	240,162	83,638	31,909	355,609
1915	858	34	267	1,159

[a] Figures for 1916 not available.

Stocks of petroleum at Batum, Russia, Dec. 31, 1911–1915.[a]

	1911		1912		1913		1914[a]		1915	
	Poods.	*Bbls.*	*Poods.*	*Bbls.*	*Poods.*	*Bbls.*	*Poods.*	*Bbls.*	*Poods.*	*Bbls.*
Illuminating	2,216,007	278,251	3,384,654	423,082	1,777,723	222,215	.....	.....	227,000	27,251
Lubricating	888,605	108,631	2,000,475	245,657	1,458,011	178,240	.....	.....	1,313,000	157,623
Solar oil, Vaseline, Residuals	300,585	35,880	963,794	107,088	1,063,459	118,162	.....	.....	1,713,000	205,642
	3,405,197	422,762	6,357,923	775,827	4,299,183	518,617	2,418,000	290,276	3,253,000	390,516

[a] Details for 1914 and 1916 not available.

GALICIA.

GENERAL STATEMENT.

Available statistics relating to the production of petroleum in Galicia in 1916 indicate that substantial progress was made in that year toward restoring the Galician fields to their normal productivity. The gain in yield compared with 1915 was about 55 per cent.

The dependence of the German and Austrian military authorities on the Galician oil fields until late in 1916 for the greater part of their supply of motor fuels and lubricating oils resulted in a high-level market for crude oil in all the Galician districts that served as a decided spur to activity in drilling throughout 1916. Prices of crude oil averaged about 19.50 kronen per 100 kilos, equivalent to about $5.50 a barrel, during the year.

PRODUCTION.

Petroleum produced in Galicia, 1912–1916, in metric tons.[a]

Field.	1912	1913	1914	1915	1916
East Galicia:					
Tustanowice	856,440	691,382	[b] 356,447		
Borysław	170,500	205,904	[b] 116,613		
Schodnica, Urycz, Mraznica, Other fields					
West Galicia:					
Potok, Rogi, Rowne, Krosno, Tarnawa-Wielopole-Zagorz, Kobylanka, Kryg, Zalawie, Lipinki, Libusza, etc.	160,067	190,000	.....	578,388	898,670
	1,187,007	1,087,286	[b] 700,000	578,388	898,670

[a] 1 metric ton=7.1905 barrels of crude petroleum of 42 gallons=2,204.62 pounds.
[b] Figures for first six months only.

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Petroleum produced in Galicia, 1907–1916.

Year.	Metric centners.[a]	Barrels of 42 gallons.	Year.	Metric centners.[a]	Barrels of 42 gallons.
1907	11,759,740	8,455,841	1912	11,870,070	8,535,174
1908	17,540,220	12,612,295	1913	10,872,860	7,818,130
1909	20,767,400	14,932,799	1914	[b]7,000,000	5,033,350
1910	17,625,600	12,673,688	1915	5,783,880	4,158,899
1911	14,629,400	10,519,270	1916	8,986,700	6,461,706

[a] 1 metric centner or quintal=100 kilograms (220.462 pounds); 1 metric centner or quintal of crude petroleum=0.71905 barrel of 42 gallons.
[b] Estimated.

IMPORTS AND EXPORTS.

Petroleum imported into and exported from Austria-Hungary in 1911–1913,[a] in metric tons.

Kind.	1911		1912		1913	
	Imports.	Exports.	Imports.	Exports.	Imports.	Exports.
Illuminating oils	1,517	265,378	1,377	383,183	1,868	285,445
Lubricating and other oils	18,213	91,065	19,687	155,583	27,037	155,907
Benzine	10	41,904	89	68,698	2,683	49,773
Paraffin	631	37,940	546	51,594	300	43,101
Crude petroleum	19,020	610	17,873	1,660	19,134	1,112
Ozokerite	.....	.....	150	2,525	146	2,275
Ceresin	.....	.....	39	1,712	16	1,550
	39,391	436,467	39,761	664,955	51,184	539,163

[a] Statistics for 1914, 1915, and 1916 not available.

RUMANIA.

GENERAL STATEMENT.

To the petroleum industry of Rumania the year 1916 brought disaster from which it will probably never fully recover. This came as a consequence of the entrance of Rumania into the great war on the side of the Entente Allies in September and the subsequent defeat of her armies on the Austrian and Bulgarian frontiers followed by invasion of her territory by the armies of the Central Powers.

With the evacuation of Bucharest at the end of November it became apparent that the capture of the Rumanian oil fields was one of the principal objectives of the invasion, and drastic steps were taken to prevent a repetition of the success that had attended the fall, in October, of Constantza, with its enormous stocks of crude oil and of refinery products awaiting export via the Black Sea. Under the direction of Col. Norton Griffiths, of the British Army, a systematic campaign of oil-field destruction was carried out. This included, according to press reports, the destruction of derricks and drilling machinery, the plugging and filling of wells, the wrecking of refineries, pipe lines, and storage facilities, and the burning of immense stores of crude oil and of refined products that had been accumulating in the fields and at adjacent storage centers since the closing of the Dardanelles and the curtailment of Rumanian exports early in the war. From all reports it appears that the destruction of the industry was so thoroughly effected that the fields could be replaced on a producing basis only at the expense of drilling new wells.

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Such statistics as are available concerning the petroleum industry in Rumania in the early part of 1916 indicate moderate activity, hampered by increasing stocks of crude oil and of refinery products at Constantza and at inland and field points, by scarcity of labor due to the mobilization of the Rumanian Army, and by the scarcity and high cost of drilling supplies.

The urgent need by the Central Powers for greater supplies of petroleum and petroleum derivatives than the Galician fields are able to furnish will undoubtedly lead to prompt and energetic methods to reestablish the Rumanian fields.

An important event in the development of the petroleum industry that took place a few days before Rumania's declaration of war was the completion of a Government-owned pipe line, 140 miles long, from Baicoi to Constantza, through which it was proposed to transport oil direct from field sources to this important Black Sea port for 2 centimes per ton per kilometer, or about 0.1 cent per barrel per mile.

PRODUCTION.

Petroleum produced in Rumania in 1915 and 1916, in metric tons.[a]

Month.	Prahova.					Dambovitza.	Buzeu.	Bacau.	Total.
	Bustenari-Calinet-Bordeni.	Campina Poiana.	Moreni.	Other.	Total.				
1915.									
January	24,148	10,909	81,072	33,489	149,618	8,232	7,548	3,413	168,811
February	22,555	10,186	59,248	27,019	119,008	8,557	7,415	3,306	138,286
March	23,806	11,132	80,981	29,034	144,953	9,691	5,462	2,302	162,408
April	25,074	10,795	68,147	31,295	135,311	8,182	5,462	1,761	150,716
May	25,498	11,172	68,681	26,997	132,348	8,673	6,944	1,773	149,738
June	24,624	10,541	58,529	20,973	114,667	8,995	10,999	1,944	136,605
July	24,557	10,639	57,470	18,083	110,749	8,797	12,557	2,354	134,457
August	22,949	10,884	53,335	18,272	105,440	7,449	13,517	2,402	128,808
September	22,294	9,524	56,601	18,293	106,712	7,290	12,354	2,498	128,854
October	24,609	9,370	56,299	21,462	111,740	9,160	11,584	2,519	135,003
November	23,454	9,252	47,940	24,079	104,725	8,432	10,407	2,605	126,169
December	22,467	6,253	52,860	14,441	96,021	7,366	7,849	2,054	113,290
	286,035	120,657	741,163	283,437	1,431,292	100,824	112,098	28,931	1,673,145
1916.									
January	14,597	8,751	60,185	24,479	108,012	7,119	11,790	2,664	129,585
February	13,912	8,245	59,561	20,553	102,271	5,955	9,980	2,707	120,913
March	14,306	8,376	63,523	24,781	110,986	5,850	11,131	2,724	130,961
April	12,860	7,862	57,201	20,994	108,917	6,044	8,916	2,488	126,365
May	13,218	8,538	53,320	55,551	130,727	7,685	9,404	2,467	150,283
June	13,210	8,568	47,042	50,168	118,988	10,491	9,548	2,510	141,537
July	12,964	8,898	58,542	25,592	105,996	13,026	10,878	2,752	132,652
August	.....	.....	.....	.....	.....	.....	.....	.....	[b]125,000
September	.....	.....	.....	.....	.....	.....	.....	.....	[b]125,000
October	.....	.....	.....	.....	.....	.....	.....	.....	[b]125,000
November	.....	.....	.....	.....	.....	.....	.....	.....	[b]125,000
December	.....	.....	.....	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....	.....	.....	1,432,296

[a] 1 metric ton=7.19 barrels of 42 gallons. [b] Estimated.

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Statistics of the petroleum industry in Rumania, 1912–1916, in metric tons.

	1912	1913	1914	1915	1916 [a]
Crude oil produced	1,804,761	1,885,225	1,783,947	1,673,145	658,107
Crude oil treated at refineries	1,667,389	1,787,245	1,680,894	1,580,981	695,452
Output of refineries:					
Benzine	352,492	422,019	396,865	394,809	164,536
Illuminating oil	345,802	380,074	352,682	263,633	125,164
Lubricating oil	43,438	48,416	100,047	129,685	78,506
Residuals	898,011	906,735	807,276	765,676	313,617
Home consumption:					
Benzine	30,656	30,131	31,672	31,762	12,013
Illuminating oil	49,941	51,396	51,710	52,741	19,010
Lubricating oil	28,997	33,725	40,816	48,348	22,510
Paraffin	1,138	1,425	1,416	1,849	925
Residuals	540,385	560,492	524,254	501,943	262,365
Fuel at the refineries	140,590	135,728	134,324	166,189	.....
Exports:					
Benzine	173,817	237,168	164,143	13,132	.....
Illuminating oil and distillate	353,563	418,622	297,800	272,899	100,897
Crude, residuals, etc	318,443	380,077	191,545	142,816	177,047
Paraffin	600	579	536	243	.....
Stocks on hand Dec. 31:					
Crude (pipe line and refinery)	.....	.....	[b] 200,000	[b] 250,000	.....
Benzine	60,647	66,746	[b] 500,000	[b] 800,000	.....
Illuminating oil	126,009	145,446			
Lubricating oil and residuals	227,140	79,766			

[a] Figures for 5 months ending May 31, 1916. [b] Approximate.

Percentages of petroleum produced in Rumania, 1911–1915,[a] by departments.

Department.	1911	1912	1913	1914	1915
Prahova	89.67	89.51	89.00	86.03	85.54
Dambovitza	4.47	4.11	2.21	2.78	6.03
Buzeu	4.08	4.83	6.66	8.38	6.70
Bacau	1.78	1.55	2.13	2.81	1.73
	100.00	100.00	100.00	100.00	100.00

[a] Figures for 1916 not available.

Percentages of refined products from Rumanian crude petroleum, 1911–1915.[a]

Product.	1911	1912	1913	1914	1915
Crude benzine	18.6	21.2	23.6	23.6	24.9
Illuminating oil	22.3	20.7	21.3	21.0	16.7
Lubricating oil	1.8	2.6	2.7	5.9	8.2
Residue	55.8	53.8	50.7	48.0	48.5
Loss	1.5	1.7	1.7	1.5	1.7

[a] Figures for 1916 not available.

Wells completed in Rumania in 1916.

District.	Jan. 1, 1916.						July 31, 1916.					
	Bore holes.			Hand wells.			Bore holes.			Hand wells.		
	Producing.	Being drilled.	Abandoned.	Producing.	Being drilled.	Abandoned.	Producing.	Being drilled.	Abandoned.	Producing.	Being drilled.	Abandoned.
Prahova	805	294	543	93	235	312	856	273	546	99	206	294
Dambovitza	35	30	41	44	1	47	23	27	16	58	14	141
Buzeu	21	27	14	56	21	144	93	40	46	44	3	47
Bacau	65	11	40	360	22	462	71	10	50	360	22	462
	976	362	643	553	279	965	1,043	350	658	561	245	944

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Petroleum products exported from Rumania in 1912–1916, in metric tons.

Kind.	1912	1913	1914	1915	1916a
Crude oil, gas oil, lubricating oil, and residuals	318,443	380,077	191,545	142,813	98,093
Illuminating oil	353,563	418,622	297,800	272,900	112,943
Benzine	173,817	237,168	164,143	13,131	3,691
Paraffin scale	600	579	536	243	.....
	846,423	1,036,446	654,024	429,087	214,727

a Figures are for 6 months ending July 31, 1916.

BRITISH ISLES.

GENERAL STATEMENT.

Scotland.—In spite of severe difficulties resulting from the shortage of labor and the high cost of necessary supplies the shale-oil industry of Scotland, which comprises the only important source of petroleum thus far developed in the British Isles, enjoyed a year of prosperity by reason of the insistent demand for its products that exceeded all experience or expectation. Since the beginning of the war the Scottish shale-oil industry has played an increasingly important part in its conduct because of the fact that every product of this industry is in some degree at least a war essential and of the further fact that many of its products are available from no other source in the British Isles.

Oil shale produced in Great Britain, 1907–1916.

Year.	England.		Scotland.		Wales.		Total.	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
1907	.....	.....	2,690,028	$3,923,971	.....	.....	2,690,028	$3,923,971
1908	.....	.....	2,892,039	3,870,118	.....	.....	2,892,039	3,870,118
1909	40	$34	2,967,017	3,970,723	.....	.....	2,967,057	3,970,757
1910	.....	.....	3,130,280	4,189,114	.....	.....	3,130,280	4,189,114
1911	.....	.....	3,116,803	4,171,174	.....	.....	3,116,803	4,171,174
1912	.....	.....	3,184,826	3,726,425	.....	.....	3,184,826	3,726,425
1913	.....	.....	3,279,903	4,001,839	240	$341	3,280,143	4,002,180
1914	.....	.....	3,268,435	4,074,190	231	282	3,268,666	4,074,472
1915	5,976	6,779	2,992,676	4,064,501	.....	.....	2,998,652	4,071,280
1916a	.....	.....	3,000,000	4,000,000	.....	.....	3,000,000	4,000,000

a Estimated.

ITALY.

GENERAL STATEMENT.

Increasing requirements of petroleum for fuel in Italian industries and of other products of petroleum for use in the conduct of the war has resulted in the awakening of considerable interest in the petroleum resources of Italy. New companies are reported to have been organized for the aggressive exploitation of the more promising areas, and, if success is attained, there appears to be no reason why Italy should not be, in the course of a few years, self-sustaining, so far as its petroleum requirements are concerned.

Petroleum is reported to occur in Italy at Parma, Piacenza, Tuscany, Bologna, Modena, Chile, Penevento, Ancona, Rome, Caserta,

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Potenza, Reggio, Girgenti-Catania, Palermo, and Lipari Islands, and for many years a small production has been obtained from wells at Valleia, Montechine, Montechiare, Neviane, and San Giovanne d'Incarico.

The following statistics are taken from the Rivista del Servizio minerario:

Petroleum produced in Italy, 1907–1916.

Year.	Number of wells in operation.	Quantity.		Value.	
		Metric tons.[a]	Barrels of 42 gallons.	Lire.[b]	Dollars.
1907	13	8,327	59,875	1,663,300	321,017
1908	14	7,068	50,966	1,415,640	273,219
1909	12	5,895	42,388	1,178,060	227,481
1910	9	7,069	50,830	1,413,900	272,863
1911	9	10,390	74,709	1,454,000	280,737
1912	9	7,479	53,778	1,196,640	230,952
1913	9	6,564	47,198	1,641,000	316,713
1914	7	5,542	39,849	1,385,500	267,402
1915	7	6,105	43,898	1,712,700	330,551
1916[c]	7	6,000	43,143	1,700,000	328,100

[a] 1 metric ton, crude=7.1905 barrels. [b] 1 lira=$0.193. [c] Estimated.

GERMANY.

GENERAL STATEMENT.

Inability to procure official information as to the trend of the German petroleum industry has necessitated an estimate of the petroleum output in this country during the last four years. Although the minor fields in Alsace-Lorraine and Hanover have undoubtedly been worked to capacity since 1914, their capabilities of response to intensive development are not believed to be such as to warrant an estimate of materially increased production.

Petroleum produced in the German Empire, 1907–1916.

Year.	Alsace-Lorraine.	Prussia.	Total.		Total value.	
	Metric tons.	*Metric tons.*	*Metric tons.*	*Barrels (42 gallons).*	*Marks.*	*Dollars.*
1907	[a]26,124	80,255	106,379	756,631	7,056,000	1,679,328
1908	[a]28,898	113,002	141,900	1,009,278	9,942,000	2,366,196
1909	[a]29,726	113,518	143,244	1,018,837	10,118,000	2,408,084
1910	.....	.....	145,168	1,032,522	10,146,000	2,414,748
1911	.....	.....	142,992	1,017,045	10,045,000	2,390,710
1912	.....	.....	144,961	1,031,050	10,190,000	2,425,220
1913	.....	.....	[b]140,000	995,764	9,790,285	2,330,088
1914	.....	.....	[b]140,000	995,764	9,790,285	2,330,088
1915	.....	.....	[b]140,000	995,764	9,790,285	2,330,088
1916	.....	.....	[b]140,000	995,764	9,790,285	2,330,088

[a] Includes Bavaria. [b] Estimated.

1 metric ton, crude=7.1126 barrels.

PERSIA.

GENERAL STATEMENT.

No statistics are available concerning the output of petroleum from the Maidan-i-Naphtun field which is under development by the Anglo-Persian Oil Co. (Ltd.), in which the English Government is

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understood to own a controlling interest. Statistics relating to this field will doubtless be published at the termination of the war.

Recent reports[a] from Persia state that M. Khoshtaria has obtained from the Persian Government an exclusive concession for exploiting petroleum deposits in the district of Ardebil for a period of 70 years. This concessionaire is reported to represent a group of Russian capitalists. This concession, together with similar concessions in Gilian, Mazendaran, and Asdrabad, obtained last year by the same agent, is said to complete the transfer into Russian hands of all the petroleum wealth of northern Persia and to remove the foreign opposition that has in the last few years sought to dispute Russian dominance in the Caspian Provinces of Persia.

BRITISH INDIA.

GENERAL STATEMENT.

The stimulus of increased demand resulted in 1916 in a moderate gain in production of petroleum in the oil fields of India compared with 1915.

The principal source of petroleum in India is the Yenangyaung field in Burma, which is situated about 275 miles north of Rangoon, on Yenangyaung Creek about 2.5 miles above its confluence with the Irrawaddy. Deep drilling in this field, which has been an important source of oil for many years, has been a feature of developments during the last two or three years and has resulted in fair increase in production.

Second in importance among the Indian districts are the Digboi and Makum fields, in the northeastern part of Assam, about 60 miles from the Thibet border. The bulk of the oil produced in Assam comes from the Digboi fields, the areal extent of which has been materially increased in the last two years by the opening of the new pools Bappapoong and Hausapoong, 2 miles east and 5 miles east, respectively, of the original field.

In western India a small production of oil is obtained from fields of minor importance in Punjab.

Petroleum produced in India, 1907–1916.

Year.	Quantity.		Value.	
	Imperial gallons.	Barrels (42 United States gallons).	Rupees.[b]	Dollars.
1907	152,045,677	4,344,162	9,150,225	2,968,637
1908	176,646,320	5,047,038	10,530,135	3,416,327
1909	233,678,087	6,676,517	13,652,380	4,429,352
1910	214,829,647	6,137,990	12,538,905	4,068,039
1911	225,792,094	6,451,203	13,265,970	4,303,923
1912	249,083,518	7,116,672	14,629,170	4,746,190
1913	277,555,225	7,930,149	15,518,790	5,035,803
1914	259,342,710	7,409,792	14,378,475	4,664,857
1915	287,093,576	8,202,674	18,852,045	6,116,232
1916	297,189,737	8,491,137	16,791,075	5,447,584

[a] Oil, Paint & Drug Reporter, vol. 91, No. 12, p. 19, 1917 (issue of Mar. 12).
[b] The value of the rupee is taken as 32.44½ cents; 15 rupees=£1.

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Petroleum produced in India, 1912–1916, in imperial gallons.

Province.	1912	1913	1914	1915	1916
Burma	245,335,209	272,865,397	254,652,963	282,291,932	291,769,093
Eastern Bengal and Assam	3,747,359	4,688,628	4,688,547	4,550,150	5,236,890
Punjab	950	1,200	1,200	251,494	183,814
	249,083,518	277,555,225	259,342,710	287,093,476	297,189,787

JAPAN AND FORMOSA.

GENERAL STATEMENT.

The combined output of petroleum in Japan and Formosa in 1916 was about 4 per cent less than in 1915, the decrease being assignable chiefly to the fields of Akita Prefecture and to the decline in yield of the gusher wells brought in during 1916 in the Kurokawa field.

An important consequence of drilling in the Akita district in 1916 was the proof of a new field along the Urayama anticline, parallel with the similar fold on which the most prolific wells in the Kurokawa field have been drilled. The oil in the new field is reported to have a gravity of 18.5° Baumé and to be identical with the Kurokawa crude.

Despite the greater interest in development in Akita, the bulk of Japan's production of oil is still derived from the fields in Echigo (Niigata), the output from which in 1916 was slightly greater than in 1915.

According to the Petroleum Times of Tokyo, Japan, there were at the end of 1916 seven plants for the extraction of gasoline from natural gas in operation in the Nishiyama field, Echigo. Three of these, having an average daily output of 3,000 gallons, are operated by the Nippon Oil Co.; 3, having a combined daily output of 2,250 gallons, by the Hoden Oil Co.; and 1, having a daily output of 500 gallons, by the Ogura Oil Co.

A gain of 2 per cent in production resulted from increased drilling in Formosa in 1916.

The possibility of developing a supply of fuel oil for the Japanese Navy from Government-owned lands in Formosa received considerable attention in 1916.

The following figures are reported by the imperial mining bureau of the department of agriculture and commerce, Tokyo:

Petroleum produced in Japan and Formosa, 1912–1916, in koku.[a]

Field.	1912	1913	1914	1915	1916
Akita	31,365	76,830	625,719	999,223	879,188
Hokkaido	5,038	4,218	6,270	8,846	6,627
Niigata	1,419,539	1,610,117	1,761,792	1,728,687	1,733,934
Shizuoka	2,030	1,983	2,055	1,720	1,646
Yamagata	205	336	.....	.....	.....
Others	113	98	.....	.....	.....
	1,458,290	1,693,582	2,395,836	2,728,476	2,621,395
Formosa	3,040	15,933	14,708	16,651	16,966
Grand total	1,461,330	1,709,515	2,410,544	2,745,127	2,638,361

[a] 1 koku=39.7 English gallons=47.46 United States gallons=1.136 United States barrels.

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Petroleum produced in Japan and Formosa, 1907–1916.

Year.	Japan.		Formosa.		Total.	
	Koku.	*Barrels.*	*Koku.*	*Barrels.*	*Koku.*	*Barrels.*
1907	1,755,464	1,994,207	a 6,717	7,631	1,762,181	2,001,838
1908	1,815,001	2,061,841	7,310	8,304	1,822,311	2,070,145
1909	1,657,036	1,882,393	5,664	7,170	1,662,700	1,889,563
1910	1,520,458	1,727,240	3,208	4,062	1,523,664	1,730,882
1911	1,529,593	1,737,618	1,442	1,638	1,531,035	1,739,256
1912	1,458,290	1,656,617	3,040	3,454	1,461,330	1,660,071
1913	1,693,582	1,923,009	15,933	18,100	1,709,515	1,942,009
1914	2,395,836	2,721,670	14,708	16,708	2,410,544	2,738,378
1915	2,728,476	3,099,549	16,651	18,915	2,745,127	3,118,464
1916	2,621,395	2,977,905	16,966	19,273	2,638,361	2,997,178

a Estimated.

AFRICA.

EGYPT.

The production of petroleum in Egypt is restricted to the properties of the Anglo-Egyptian Oilfields (Ltd.) (Royal Dutch-Shell Syndicate), in the vicinity of Gemsah, on the west side of the Red Sea, near its confluence with the Gulf of Suez. Two fields contribute to the annual production, the Gemsah field, at Gemsah, and the Hurgada field, a few miles to the south. Production fluctuates considerably from year to year, as trouble from sand necessitates frequent shutdowns for cleaning and repairing the wells. The output in 1916 was 28 per cent greater than in 1915.

Oil from this district is transported by pipe to a small refinery at Suez, which operates in part on crude oil from foreign sources.

Petroleum produced in Egypt, 1911–1916.

Year.	Metric tons.	Barrels of 42 gallons.
1911	1,220	9,150
1912	27,454	205,905
1913	12,618	94,635
1914	103,605	777,038
1915	34,961	262,208
1916	54,800	411,000

ALGERIA.

On June 1, 1916, the properties of the Algeria Consolidated Oil Estates (Ltd.), consisting of Government leases over oil-bearing properties in the Tliouanet district, near Relizane, Department of Oran, Algeria, were transferred to the Société algérienne des pétroles du Tliouanet, in order to comply with an Algerian law that forbids the granting of a mining concession to other than a French company. Three wells have been drilled at Nehma, two of which are producing. Two additional wells were being drilled at the end of 1916.

Owing to the war, the properties of the Algerian Oilfields (Ltd.), comprising concessions of 20,000 acres in the Relizane district, Department of Oran, and including 32 wells in the M'Sila and Medjila areas, were idle during 1916.

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UNION OF SOUTH AFRICA.

GOOD HOPE (CAPE COLONY).

Vice Consul F. J. Flexer, of Port Elizabeth, Good Hope, reports [1] under date of August 2, 1916, as follows concerning the possibilities of petroleum development in that locality:

Indications of the presence of mineral oils in the district immediately surrounding Port Elizabeth have attracted the attention of a group of local capitalists, and the Uitenhage Petroleum & Mining Co. has been incorporated in South Africa under very broad articles. Papers were filed with the Government on June 15, 1916, and the full issue of one hundred £25 ($121.66) shares was immediately subscribed.

The field was surveyed by a prominent British expert, who reported the geological formation to be very similar to that of the Caucasus belt. Prospecting operations which then followed resulted unsatisfactorily. The present site was selected after consulting several prominent South African geologists, and is 3 miles from a main-line railway and 20 miles from Port Elizabeth.

It is estimated that the subscribed capital will be sufficient to sink and case a test hole to a depth of 1,500 feet, 300 of which have already been completed. Cores from various depths have been submitted to the Government's geological department, with the result that strong indications of a rich petroleum base oil were reported.

The capital is to be increased if further tests justify such a course.

MADAGASCAR.

Late in 1916 drilling was begun on the Island of Madagascar by the Betsiriry Proprietary Oil Fields (Ltd.) on the properties over which it holds prospecting licenses. In January, 1916, the Manambolo Oil Syndicate (Ltd.) was absorbed by the Betsiriry company.

Drilling was continued in 1916 on the properties of the Sakalava Madagascar Proprietary Oil Fields (Ltd.) in Betsiriry Valley, Madagascar. Well No. 1 was abandoned. Oil was found in Nos. 2 and 3, and drilling was begun on No. 4. In September this company acquired control of properties adjoining its holdings, formerly held by the Folakara Oil Fields (Ltd.)

OCEANIA.

EAST INDIES.

No developments of consequence were credited to the oil fields of the East Indies in 1916. Moderate gains in petroleum production in that year are credited to Borneo and Sumatra and a slight decrease is charged against Java. In the minor districts substantial increase in production was effected in 1916 in Ceram and in British North Borneo. In Sarawak, on the north coast of Borneo, substantial progress was made in the development of the Miri field and in the construction of a refinery and of a deep-sea pipe line to facilitate the loading of steamers.

In Papua, or New Guinea, no progress was made in 1916 in determining the extent or value of the petroleum resources known to exist along the west flank of the Albert Mountains between the mouth of Purari River and Yule Island. About 500 gallons of oil is said to have been produced from the well drilled at Upoia in 1916 under the supervision of the commission of lands and the director of mining for Papua.

[1] Commerce Reports, Sept. 20, 1916.

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Petroleum produced in Dutch East Indies, 1907–1916.

Year.	Borneo.		Java.		Sumatra.		Total.		
	Metric tons.	Liters.	Metric tons.	Liters.	Metric tons.	Liters.	Metric tons.	Liters.	Barrels.
1907	489,151	541,948,068	142,983	165,900,000	713,841	879,235,063	1,345,975	1,587,083,131	9,982,597
1908	511,049	566,209,890	137,013	158,974,000	738,588	909,715,827	1,386,650	1,634,899,717	10,283,357
1909	411,506	455,922,397	140,351	162,846,428	922,894	1,136,720,015	1,474,751	1,755,488,840	11,041,852
1910	633,472	701,853,114	142,503	165,344,877	719,740	886,505,130	1,495,715	1,753,703,121	11,030,620
1911	814,707	902,654,621	172,438	190,766,435	683,523	841,895,279	1,670,668	1,935,316,335	12,172,949
1912	671,662	744,167,950	184,989	214,641,699	621,481	765,481,929	1,478,132	1,724,291,578	10,845,624
1913	797,059	883,061,666	207,135	240,334,598	529,947	652,735,720	[a]1,534,223	1,776,227,127	11,172,294
1914	[c]931,903	1,032,455,334	226,590	262,907,845	475,423	585,578,509	[b]1,634,403	1,881,506,744	11,834,493
1915	[d]960,896	1,064,576,678	256,838	298,003,995	491,611	605,517,269	[e]1,710,445	1,969,316,632	12,386,800
1916	[f]1,047,462	1,160,483,150	243,442	282,460,884	526,080	647,972,736	[g]1,820,247	2,094,531,848	**13,174,399**

[a] Includes 82 metric tons produced in Ceram.
[b] Includes 487 metric tons produced in Ceram.
[c] Includes 65,185 metric tons produced in British Borneo.
[d] Includes 67,000 metric tons produced in British Borneo.
[e] Includes 1,100 metric tons produced in Ceram.
[f] Includes 90,067 metric tons produced in British Borneo.
[g] Includes 3,263 metric tons produced in Ceram.

1 gallon Borneo crude=7.5322 pounds.
1 gallon Java crude=7.1924 pounds.
1 gallon Sumatra crude=6.7754 pounds.
1 United States barrel=158.985 liters; 1 liter=1.0567 quarts.

AUSTRALIA.

SOUTH AUSTRALIA.

Persistent effort of the South Australia Oil Wells Co., of Melbourne, to test thoroughly the petroleum possibilities of the Robe district resulted in 1916 in deepening the test well at Robe, begun in 1915, from 1,575 feet in November, 1915, to 3,975 feet in mid-December, 1916. More or less colorless and odorless gas displaying the physical properties of methane was found in a succession of black carbonaceous shales encountered at about 3,500 feet. Drilling in this well was still in progress at the end of 1916, and on March 31, 1917, a depth of 4,407 feet had been attained.

QUEENSLAND.

Under the supervision of the minister of mines for Queensland drilling was begun in 1916 on a test well at Roma, on the south flank of the Carnarvon Range, in the southeastern part of Queensland. On July 6, 1916, the well had attained a depth of 600 feet.

NEW SOUTH WALES.

The deposits of oil shale in Capertee Valley, in the Blue Mountain region, constitute at present the only source of petroleum thus far developed in New South Wales. The mining and distillation of kerosene shale, as it is called, in this district is conducted by the Commonwealth Oil Corporation (Ltd.) and the British Australian Oil Co. (Ltd.). A moderate gain in quantity of shale mined and retorted in 1916, compared with 1915, is shown in the table on next page.

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Oil shale produced in New South Wales, 1907–1916.

Year.	Quantity (long tons).	Value.	Year.	Quantity (long tons.)	Value.
1907	47,331	$154,996	1912	a 86,018	$169,208
1908	46,303	126,855	1913	a 16,985	35,715
1909	48,718	114,932	1914	50,049	133,205
1910	68,293	164,955	1915	15,474	62,729
1911	75,104	179,963	1916	17,425	86,487

a Estimated.

The average recovery of oil from this shale is about 80 United States gallons to the ton.

TASMANIA.

On the basis of an offer from the Australian Government to purchase 8,000 tons of oil a year for eight years for the use of its navy, the premier of Tasmania submitted in 1916 to the Tasmanian Legislative Council a proposal involving the purchase and operation by the Tasmanian Government of the shale oil properties of the Railton-Latrobe Shale Oil Co. Adverse action on this proposal by the legislative council served to postpone, at least until the end of the war, any extensive development of these reserves of what has been termed to be "one of the best fuel oils in the world."

The quantity of shale mined and retorted in Tasmania in 1916 was 1,286 tons, valued at $6,258.

Drilling was begun in 1916 by the Bruny Island Petroleum Co. of a wildcat test on Bruny Island, Tasmania.

NEW ZEALAND.

The usual small production of crude oil was obtained in 1916 from deep wells in the Taranaki district, near New Plymouth, North Island.

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GEMS AND PRECIOUS STONES.[1]

By WALDEMAR T. SCHALLER.

NO VALID DISTINCTION BETWEEN PRECIOUS AND SEMIPRECIOUS STONES.

The United States Geological Survey is often asked to make a distinction between precious and semiprecious stones, and especially to state the class in which some particular mineral belongs. To the popular mind the diamond, ruby, sapphire, and emerald are the true precious stones; all others are semiprecious. The popular mind, however, is not consistent from time to time; the fickleness of fashion may readily change the standing of gems; and demand and supply, popular taste, and price may affect the rank of a precious stone.

Gem stones are desired for personal adornment because of their rarity, their cost, and especially their beauty, and these items probably determine as much as any other the classification of gem stones. But can agreement ever be reached as to what are the most beautiful of all gem stones? The opinion and taste of the wearer, of the jeweler, and of the scientist all deserve consideration, but the three can probably not reach a satisfactory agreement.

In short, no criteria of subdivision between precious and semiprecious stones can be offered on which all gem stones can be classified. All stones which are suitable for personal adornment and which please the wearer may be called precious stones. Jasper is as much a precious stone as diamond. The schemes of classification of gem stones into precious and semiprecious are almost as numerous as the books written on the subject, but not even all the authors can retain their classification throughout. One author, in his table of contents, divides gem stones into (*a*) precious stones (diamond, corundum, and beryl); (*b*) semiprecious stones (topaz, spinel, garnet, etc.); (*c*) ornamental stones (fluor, lapis lazuli, sodalite, etc.); and (*d*) organic products (pearl, coral, amber); yet, in his text, he says: "Once contemptuously styled common garnet, andradite suddenly sprang into the rank of precious stones."

The properties that give minerals value as gem stones are color, luster, transparency, hardness, and rarity. The first three are sometimes grouped together under the head of beauty. It has been said that a mineral must possess at least a majority of these properties in order to be ranked as a precious as distinguished from a semiprecious stone. An attempt to apply the test will show the futility of any such subdivision. The application of such a subdivision would also

[1] The tables in this chapter giving statistics of the values of the gems and precious stones produced in 1916 were compiled by Miss Blanche H. Stoddard.

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relegate a good many specimens of every mineral species to the semiprecious class; thus a diamond that is dull in appearance, gray in color, and only translucent (not transparent) could then not be classed as a precious stone, for such a crystal would lack all beauty, and the diamond is not the rarest of gem stones. Further, only certain varieties of the mineral corundum and of beryl could be called precious; the vast bulk of these minerals would be only semiprecious.

Color can not furnish a satisfactory basis of division for, in addition to corundum (ruby), many red minerals are used as gem stones, such as spinel, garnet, opal, jasper, fluorite, and tourmaline; in addition to sapphire, many blue minerals are used, such as benitoite, sodalite, fluorite, turquoise, azurite; and many green minerals, such as feldspar, fluorite, tourmaline, variscite, malachite, and hiddenite. Absolute lack of color, characteristic of some diamonds, is also shown by many other gem stones, such as quartz, beryl, phenacite, and topaz.

Luster and transparency vary considerably, not only in the same mineral but even in the same crystal. The presence of impurities or flaws may have a marked effect on the luster of a mineral, so that two crystals of the same mineral may exhibit very different degrees of luster and transparency.

Hardness can not be a deciding factor, unless it is said that all minerals must have a hardness of 9 or more in order to rank as precious stones; but this requirement would exclude emerald, which has a hardness ranging from 7½ to 8. If the limit is placed at 7½ to 8 (that of emerald), then chrysoberyl (8½), topaz (8), phenacite (7½ to 8), and perhaps a few others like the minerals of the spinel group (7½ to 8) would have to be included.

The rarity of gem stones has often been set up as a criterion of their value. It may be true that, in general, a very rare gem is of greater value than an equally attractive but more abundant one, but the rarity of a stone may be offset by its properties. The diamond is by many people regarded as extremely rare, but in comparison with such gem stones as benitoite, hiddenite, and many others it is very abundant.

The foregoing statements are intended to show that gem stones can not logically be classified as either precious or semiprecious and that neither cost, beauty, hardness, nor rarity, whether considered separately or together, can be made to serve as an exact basis of such a classification. Of course, an arbitrary classification of gem stones may be proposed, but it is not likely to be universally adopted, especially if it ignores the particular properties, such as color and hardness, that characterize gem stones in general.

PRODUCTION.

From the beginning of this century to 1914 the value of the precious stones annually produced in the United States has been about a third of a million of dollars. The lowest value, $208,000, was reported in 1906; the highest, $534,280, in 1909. During the first year of the war (1914) the value of the production ($124,651) dropped to the lowest figure reported since 1896. There has been a steady increase since 1914 in the value of the precious stones pro-

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duced, that for 1915 being $170,431 and that for 1916 being $217,793, an increase in 1916 of 28 per cent over the value in 1915, and of 75 per cent over the value in 1914. The value for 1916, however, has not yet reached the general average, being less than that of any year since 1900, except 1906, 1914, and 1915.

Value of precious stones produced in the United States, 1912–1916.

	1912	1913	1914	1915	1916
Benitoite	$150				
Beryl	4,140	$1,615	$2,395	$1,675	$2,031
Copper ore gems	1,085	2,350	1,280	1,120	1,713
Corundum	197,765	288,835	61,032	88,214	99,180
Diamond	1,475	6,315	765	608	2,680
Epidote	10				(a)
Feldspar	1,310	1,285	449	368	305
Garnet	860	4,285	1,760	4,523	1,542
Hematite				126	
Jade			300		
Kyanite	10			(a)	
Opal	10,925	15,130	1,114	1,850	1,888
Peridot	8,100	375	100	(a)	455
Phenacite				(a)	
Pyrite	265	50		1,042	2,075
Quartz	21,779	16,861	18,838	35,724	25,707
Rhodonite	550	165	1,050	85	(a)
Rutile				(a)	(a)
Smithsonite	650	50	50	(a)	
Spodumene	18,000	6,520	4,000	(a)	(a)
Thomsonite	800		21	(a)	47
Topaz	375	736	1,380	862	1,005
Tourmaline	28,200	7,630	7,980	10,969	50,807
Turquoise	10,140	8,075	13,370	11,691	21,811
Variscite	8,450	6,105	5,055	3,867	3,140
Vesuvianite	275	152	1,425	1,535	(a)
Miscellaneous gems	4,408	2,920	2,287	b 6,172	c 3,452
	319,722	319,454	124,651	170,431	217,793

a Small production included under "miscellaneous gems."
b Includes apatite, calamine, chlorastrolite, crocidolite, datolite, fossil coral, Iceland spar, kyanite, lazurite, obsidian, peridot, phenacite, rutile, smithsonite, spodumene (kunzite), staurolite, thomsonite, titanite, and zircon.
c Includes chlorastrolite, datolite, epidote, fossil coral, hematite, kyanite, lasulite, rhodonite, rutile, sepiolite, serpentine, spodumene, staurolite, and vesuvianite.

The marked irregularity in the value of the output of any one gem stone from year to year is due mostly to the very irregular mode of occurrence of many gem stones and to the fact that most of the producers carry on their work in gem finding as an incident to other work and therefore do not put much money or much time into it. Most of the value recorded represents the output of a few large companies, but by far the greater number of producers carry on gem mining very differently from other mining.

The value given in the table largely represents the first value of the rough material; the value of the cut and polished gems is several times greater. The completeness and accuracy of the statistics of production depend on the assistance of the gem miners and dealers, and their help is greatly appreciated. The Geological Survey carries on a large correspondence concerning precious stones, and the accurate information furnished by the individual producers enables the Survey to put intending purchasers of rough material directly in touch with them.

The principal precious stones produced in the United States during recent years are corundum, quartz, tourmaline, and turquoise. These four minerals have yielded 86 per cent of the total value of

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precious stones produced for the years 1911 to 1916. The value of the corundum produced during the same period averages 58 per cent of the total production. The statistics for the individual years and gems are shown in the following table:

Percentage of values of principal precious stones produced in the United States, 1911–1916.

Year.	Total value.	Corundum.[a]		Quartz.[b]		Tourmaline.		Turquoise.		Percentage of total shown by corundum, quartz, tourmaline, and turquoise.
		Value.	Percentage of total.	Value.	Percentage of total.	Value.	Percentage of total.	Value.	Percentage of total.	
1911.....	$343,692	$215,523	62	$30,227	9	$16,445	5	$44,751	13	89
1912.....	319,722	197,765	62	21,779	7	28,200	9	10,140	3	81
1913.....	319,454	238,835	75	16,861	5	7,630	2	8,075	3	85
1914.....	124,651	61,032	49	18,338	15	7,980	6	13,370	11	81
1915.....	170,431	88,214	52	35,724	21	10,969	6	11,691	7	86
1916.....	217,793	99,180	46	25,707	12	50,807	23	21,811	10	91
Average for 1911–1916...			58	.....	12	.....	9	.....	8	86

[a] Includes ruby and sapphire.
[b] Includes all varieties of quartz, such as amethyst, rock crystal, chalcedony, agate, jasper, etc.

Reports of production were received from 96 persons and companies. A few of these are either lapidaries or collectors and not regular producers of precious stones. On the other hand, there may be some producers whose reports are not received by the United States Geological Survey, so that it may be estimated that in 1916 the producers of precious stones in the United States numbered about 100. Thirty-four distinct mineral species were mined; including all varieties as reported, a total of 79 named precious stones were produced. These came from 27 States, 9 of which had a production valued at more than $1,000 each. Thirteen States produced only one gem mineral.

RANK OF STATES.

Montana led all the other States in the value of precious stones produced in 1916, as it has done for the last six years. The output consisted chiefly of corundum (sapphire), which constituted almost one-half of the total value of all precious stones produced in the United States in 1916. Moss agate was also a considerable item, the value ranking next to that of sapphire; garnet, amethyst, and Iceland spar are also included in the production of 1916.

California ranked second in the value of the output of precious stones. The larger items were tourmaline and quartz (jasper, chalcedony, agate, chrysoprase, rock crystal, smoky quartz, rose quartz, and gold quartz); small quantities of beryl, garnet, topaz, diamond, rhodonite, serpentine, spodumene, turquoise, and vesuvianite were also included.

Nevada produced chiefly turquoise, and also some opal and variscite.

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Colorado produced various precious stones. Turquoise, pyrite, and quartz had the greatest value, and those of less value were garnet, covellite, and topaz.

Maine yielded tourmaline, spodumene, topaz, beryl, garnet, and quartz.

Arizona produced turquoise, garnet, copper-ore gems, agate, peridot, obsidian, tourmaline, and turquoise.

Value of precious stones produced in 1916, by States.

Montana	$108,263
California	54,885
Nevada	15,734
Colorado	10,818
Maine	8,458
Arizona	4,878
Oregon	4,492
Utah and Arkansas	5,515
Other States[1]	4,750
	217,793

In the number of distinct minerals mined for their value as precious stones (grouping chalcedony, jasper, rock crystal, smoky quartz, amethyst, etc., as one mineral—quartz), California leads with 11 and is followed in order by Arizona with 9, Colorado, North Carolina, and Pennsylvania with 7 each, Maine with 6, and Montana and Texas with 5 each.

NOTES ON INDIVIDUAL PRECIOUS STONES.

BERYL.

Five States reported a production of beryl in 1916, namely, California (colorless, pink, and aquamarine), Maine (colorless, aquamarine, and golden), North Carolina (colorless, aquamarine, blue, green, and golden), Connecticut, and New Hampshire.

Mr. Rolf A. Schroeder, 53 Westbourne Terrace, Brookline, Mass., reports the occurrence of gem beryl in small quantities at Rollstone Hill, Fitchburg, Mass. The beryl occurs sparingly in the pegmatite dikes that cut the granite on the west side of the hill. The pegmatite and granite are crushed as soon as quarried, and many fine beryl crystals have doubtless been lost. The beryl is pale yellowish green, rarely golden, but never blue. Mr. Schroeder states that he found half a dozen crystals which yielded cut stones weighing from one-half to 1 carat. A single larger crystal yielded a cut stone weighing 2½ carats. A matrix specimen showed pegmatite with white feldspar and granular glassy quartz of a smoky-gray color, similar to that of Royalston, Mass. An embedded bluish crystal was clear where it lay in the quartz but fractured and opaque where it was inclosed in the feldspar. A cut stone weighing 1.1 carat, kindly lent by Mr. Schroeder for examination, was of rather pale color but very brilliant and showy. There was apparently no production of gem beryl from this locality in 1916.

[1] Connecticut, Idaho, Indiana, Kansas, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Mexico, New York, North Carolina, Oklahoma, Pennsylvania, Texas, Virginia, Washington, Wyoming. Production of each State less than $1,000.

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DIAMOND.

A small production of diamonds from Arkansas is reported. A number of diamonds were found in 1916 by L. J. Wagner, the watchman at the Arkansas mine owned by the Arkansas Diamond Co. The modern though small washing plant of the Kimberlite Diamond Mining & Washing Co. on the bank of Prairie Creek at Kimberley was operated almost continuously in making further tests of the ground on the Mauney and Ozark mines and in complying with the terms of the lease held by this company on the Mauney mine. For a number of years neither of these companies has reported to the United States Geological Survey a production of stones, so that the values given in the table on page 889 under diamond, having been moderately estimated, may be too small.

The American mine, formerly owned by the American Diamond Mining Co. but now owned by T. E. Flournoy, of Monroe, La., and the Kimberlite mine, owned by the Kimberlite Diamond Mining & Washing Co., were idle. Neither was work done at the "Black Lick," where peridotite has been found.

A report on the diamond-bearing areas of Arkansas is now in preparation by H. D. Miser, of the United States Geological Survey.

Isolated diamonds continue to be found in Cherokee Flat, Butte County, Cal. The weights of three such stones, reported as found in 1916, are 1.2, 0.73, and 0.54 carats, respectively.

Another diamond was found in Brown County, Ind., by J. W. Cornett, of Martinsville, Ind., who reports that the stone was found in the gravel of the bed of Lick Creek, about 15 miles southeast of Martinsville. The associated minerals are gold, garnet, and corundum (sapphire and ruby). Mr. Cornett kindly sent the stone to the United States Geological Survey for examination.

The diamond is fairly clear and decidedly yellowish in color. Its dimensions are 4.5 by 6 by 7.5 millimeters. It weighs 0.2966 gram or 1.48 carats. Its density is about 3.54. It is a rounded rhombic-dodecahedron, elongated slightly in the direction of an octahedral axis. The crystal was originally bounded by 12 flat faces of the dodecahedron but in its present form it is bounded by 24 curved surfaces. This doubling of the number of faces is due to a peculiar form of corrosion by which each flat dodecahedral face was replaced by two curved faces. The boundary lines (on each originally flat dodecahedron face) where two corrosion streams met, which are also the line of contact of the two replacing faces, are, on the smaller dodecahedral faces, fairly straight and symmetrical, but on some of the larger and elongated dodecahedral faces the boundary lines are very oblique and curved so that some of the original faces have been divided into two very unequal parts. The crystal resembles very closely the one from German Southwest Africa, described and illustrated by Fersmann and Goldschmidt[1] in the atlas of their work on the diamond.

The surfaces of the Indiana crystal are considerably pitted with small markings, which appear to be irregular but which, observed under low magnification, are readily seen to consist in part of paral-

[1] Fersmann, A. V., and Goldschmidt, V., Der Diamont, pl. 30, fig. 207 (crystal 95), Heidelberg, 1911.

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lel structures which are oriented with reference to crystallographic directions in the diamond. Striations and well-defined etch figures are absent.

DUMORTIERITE.

Two new localities of the hydroborosilicate of aluminum, dumortierite, have been recently found. One is in New Mexico and the other in Nevada. This mineral, until recently considered very rare, has now been found in seven States—New York, Colorado, Washington, New Mexico, Nevada, Arizona, and California, in the last four of which it occurs in abundance.

The New Mexico locality is about 100 miles west of El Paso, 12 miles northwest of Columbus, in the Tres Hermanas Mountains, southern New Mexico. This deposit of dumortierite has been referred to in the press as lapis lazuli. The ledge containing dumortierite is said to be several feet wide with an outcrop of over 1,000 feet. Many boulders with seams of the mineral lie on the ground. A sample sent to the Geological Survey by W. A. Casler, of Deming, N. Mex., shows a quartz rock, in part sericitized, with narrow seams a quarter of an inch wide and the same distance apart, composed of spherulites of blue dumortierite with smaller amounts of colorless spherulites of similar structure, which are formed of mica. In places the mica spherulites appear to have been derived from the alteration of the dumortierite; at other places the two minerals seem to be intergrowths. If large pieces suitable for cutting and polishing are obtainable, the occurrence should yield a striking ornamental stone, for the narrow seams of bright blue dumortierite in the white rock afford a very attractive contrast. Well-selected and cut pieces, with a narrow band of the dumortierite, might also yield cut stones of value in jewelry.

Nevada also has an extensive deposit of dumortierite, and Adolph Knopf, of the United States Geological Survey, has kindly furnished the following note on the occurrence:

> Dumortierite occurs in great abundance in the Rochester district, in Humboldt County, Nev. On the west flank of Lincoln Hill in this district there is a large area of Triassic rhyolites that are cut by innumerable veinlets composed of dumortierite and quartz. The rock inclosed between the veinlets has been highly altered to an aggregate consisting of andalusite, quartz, dumortierite, and white mica. The dumortierite of this Nevada occurrence is prevailingly lavender and pink in color, the blue, usually thought to be characteristic of dumortierite, being very rare. The veinlets, so far as is now known, range from a friction of an inch to 6 inches in thickness. The thicker veinlets consist more largely of quartz than the smaller ones, and some of this quartz is noteworthy because of its fine rose color. Between this rose-colored quartz and the pure pink dumortierite all stages of gradation due to intergrowth can be seen, and under the microscope the clear rose-colored quartz is found to inclose numerous hair-like fibers of dumortierite, to which the color of this new variety of rose-colored quartz is due.
>
> By careful prospecting of the area in which the dumortierite occurs it is possible, though by no means certain, that rose-colored quartz of a quality suitable for polishing as a precious stone may be found.

GARNET.

Small quantities of garnets are produced each year in several of the States. In 1917 the mineral of gem quality was obtained from Arizona, California, Colorado, Idaho, Maine, Montana, New York,

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North Carolina, and Pennsylvania. The pegmatite veins of the gneiss of Manhattan Island, New York City, has yielded some very large garnet crystals, two of which weigh 10 pounds 8 ounces and 9 pounds 10 ounces, respectively. Such material, however, is of little gem value. In October, 1916, in the Washington Heights section of New York City, in the block bounded by Haven and Northern avenues and West One hundred seventy-eight and West One hundred seventy-ninth streets, James G. Manchester found an incomplete crystal, about 3 inches in diameter, of fine gem quality. A qualitative chemical examination demonstrated that the material was the aluminum-manganese species, spessartite, only very small amounts of iron, calcium, or magnesium being present. Although the New York material is similar to the spessartites of Amelia Court House, Va., Manchester and Stanton[1] describe it as "more brilliant, more perfect, more translucent and of a more beautiful color, being a clear, slightly orange-red, rather than the cloudy brownish red." The material cut into 39 brilliant and step-cut stones, of a combined weight of about 19 carats. The largest stone weighed 1.37 carats.

QUARTZ.

The varieties of quartz produced in 1916 include agate, agate jasper, agatized wood, amethyst, bloodstone, carnelian, common chalcedony, citrine, blue and green chrysoprase, jasper, jasperized wood, moss agate, rock crystal, rose quartz, smoky quartz, gold quartz, milky quartz, rainbow quartz, touchstone, and quartz with inclusions of dumortierite, hornblende, or rutile.

Mr. Shelley W. Denton, Wellesley, Mass., reports finding near his home pale lavender-colored quartz crystals (amethyst) loose and imbedded in a fine mud which filled cavities in veins of quartz. Many gems of this material were cut and sold under the name lavendine.

A new variety of rose-colored quartz from Nevada, suitable for cutting into gem stones, is described under dumortierite.

The itemized production of quartz gems is shown below:

Value of quartz gems produced in 1912–1916.

	1912	1913	1914	1915	1916
Chalcedony [a]	$9,978	$8,920	$8,312	$23,262	$19,111
Amethyst	363	389	255	122	494
Chrysoprase	220	.....	75	1,050	650
Gold quartz	1,900	300	1,050	(b)	1,077
Jasper [c]	6,005	5,275	4,700	8,508	1,667
Rock crystal [d]	2,448	1,640	4,046	[e] 2,437	[f] 2,241
Rose quartz	865	337	400	350	467

[a] Includes agate, carnelian, common chalcedony, moss agate, onyx, and prase.
[b] Small production of gold quartz included under rock crystal.
[c] Includes common jasper, bloodstone, jasperized wood, and touchstone.
[d] Includes citrine, smoky quartz, and quartz with inclusions.
[e] Includes a small amount of gold quartz.
[f] Includes small amounts of rainbow quartz, milky quartz, and sapphire quartz.

[1] Manchester, J. G., and Stanton, G. S., A discovery of gem garnet in New York City: Am. Mineralogist, vol. 2, pp. 85–86, 1917.

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TOURMALINE.

The values of the production of tourmaline in 1916 was considerably greater than for any year since 1910 and almost twice as much as that of the last three preceding years (1913, 1914, 1915) combined. The largest production came from California. A smaller output was reported from Maine, and R. L. Balke, of Phoenix, Ariz., reported that pink and green tourmalines were found near Wickenburg, Maricopa County, Ariz.

An exhibit of the occurrance of gem tourmaline and associated spodumene (kunzite) from California has been prepared in the National Museum, at Washington, D. C. This exhibit is described on pages 896–898.

TURQUOISE.

The value of the turquoise produced in 1916 was about double that of any one of the preceding four years. The production came from six States, with Nevada in the lead and Colorado second.

E. S. Larsen, of the United States Geological Survey, has kindly submitted the following description of the turquoise mine near Manassa, San Luis Hills, Conejos County, Colo.:

The mine is owned by Mr. C. G. King, of Manassa, Colo., and has been worked for the last 10 or 12 years, at times leased on shares, at times for a cash rental. The mine is in a low hill rising only about 100 feet above the surrounding rolling country. It is worked by an open cut. There are some old tunnels and shafts near by. The turquoise is largely sold or traded to Indians of New Mexico.

The mine is about 9 miles southeast of the town of Manassa, Conejos County, Colo., and lies in an altered andesitic rock of considerable size which crops out as a light-colored streak striking about northwest across the low hills. At the turquoise mine this altered rock is traversed by closely spaced fracture planes running in various directions. Along these planes there is commonly a deposit, half an inch in maximum thickness, of a white to yellowish mineral, probably one of the amorphous or minutely crystalline hydrous aluminum phosphates. Locally these fracture planes also carry turquoise, which has been found only in the small area included in the one mine. The zone of fractured, altered rock is 100 feet or more across and appears to carry some turquoise throughout.

IMPORTS.

The precious stones (excluding pearls) imported into the United States in 1916, as reported by the Bureau of Foreign and Domestic Commerce, Department of Commerce, were valued at $38,930,117. Pearls are omitted from the total value, as they are lustrous calcareous concretions with animal membrane between successive layers and are not a mineral but an animal product, being deposited in the shells of various mollusks. As pearls owe their beauty and value to the organic part of their composition, they do not come within the scope of this report. They are, however, among the most desired of gems, and their value is therefore given in a separate column in the table of imports.

Including pearls, the value of imported gems in 1916 was the highest thus far reported. For the years 1909 to 1913, inclusive, the average value of the imported precious stones (exclusive of pearls) approximated closely $40,000,000, but in 1914 this fell more than 50 per cent; there was a slight recovery in 1915 and a full recovery in 1916.

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The value of the domestic production of precious stones shows a similar decrease for the years 1914 and 1915 as compared to the five-year period 1909–1913, but the production in 1916 has not recovered to the average value for 1909–1913, being in fact but little more than half as much. If the average values of the domestic production and of imports for the years 1909 to 1913, inclusive, are taken as the standard, the production in 1914 was valued at 34 per cent and the imports (exclusive of pearls) at 44 per cent; in 1915 the production was 47 per cent and the imports 56 per cent; in 1916 the production was 60 per cent, the imports 99.7 per cent—almost a complete recovery.

Diamonds and other precious stones imported and entered for consumption in the United States, 1907–1916.

Year.	Diamonds.				Diamonds and other stones not set.	Total ex-excluding pearls.	Pearls.
	Glaziers.	Dust and bort.	Rough or uncut.	Unset.			
1907	$410,524	$199,919	$8,311,912	$18,898,336	$3,365,902	$31,186,593	$680,006
1908	650,713	180,222	1,636,798	9,270,225	a1,051,747	12,789,705	910,699
1909	758,865	50,265	8,471,192	27,361,799	a3,570,540	40,212,661	24,848
1910	213,701	54,701	9,212,378	25,593,641	4,003,976	39,078,404	1,626,083
1911	199,930	110,434	9,654,219	25,676,302	3,795,175	39,436,054	1,384,376
1912	452,810	94,396	9,414,514	22,865,686	3,405,543	36,232,949	5,130,376
1913	471,712	100,704	12,268,543	24,812,604	2,775,811	40,429,374	5,002,624
1914	579,332	77,408	2,851,933	11,476,871	1,635,522	17,121,066	2,090,018
1915	366,793	75,944	7,020,646	13,177,919	a1,078,391	21,719,693	4,513,909
1916	836,018	67,290	11,441,328	24,282,140	a2,303,341	38,930,117	11,336,971

a Including agates. Agates in 1906, $20,130; in 1907, $22,644; in 1915, $31,657; in 1916, $18,681.

EXHIBIT OF TOURMALINE AND OTHER GEM MINERALS IN THE PEGMATITES OF SOUTHERN CALIFORNIA.

The gem-bearing pegmatite region of southern California has been somewhat intensively studied by the writer under the joint auspices of the United States National Museum and the United States Geological Survey, and an exhibit representing the region has been deposited in the National Museum, Washington, D. C.

The gems are contained in one case which has three horizontal shelves and two sloping shelves. The exhibit consists of specimens of the country rocks (granite and gabbro) and of their associated pegmatite dikes, in which are found the gem tourmalines and other gem minerals. The collection is shown on the first floor, main hall, east end, of the new National Museum Building, Washington, D. C.

The nearly flat-lying pegmatite dikes, from which most of the specimens shown were obtained, crop out on the hills north and east of Pala, San Diego County, Cal., and are of the compound, unsymmetrical type whose different parts are thought to be due to differentiation processes rather than to multiple injections of material into reopened fissures. The upper portion of the dike is locally known as the "top rock" and is a mixture of a coarse, granular aggregate of quartz and feldspar and of a graphic pegmatite. No gem stones are found in this "top rock." The lower portion of the dikes, locally called the "bottom rock," is a much finer grained granular

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quartz-albite rock characterized by numerous wavy bands of brownish-red garnets. These bands lie nearly horizontal in their general trend, being parallel to the slight dip of the dike. The "bottom rock" is likewise free from gem stones, but both it and the "top rock" are of great interest from the scientific point of view. Between the "top rock" and the "bottom rock" is the middle portion, called the "pay streak" by the miners, in which the gem minerals of value are found. Here also occur the cavities or pockets which often yield an abundance of the well-crystallized minerals shown in the exhibit.

The top horizontal shelf on the south side of the exhibit case contains the granitic and gabbro country rock, and also the partly altered gabbro—a loose, friable rock—and the completely altered gabbro, which as a brown iron-stained clay has been washed into the cracks and seams of the pegmatite rock. Where such a crack extends into a pocket the clay has coated the gems and associated minerals found therein. There are shown, for example, white feldspars of the pegmatite coated with the brown clay derived from the gabbro country rock. The origin of the clay of the gem pockets is thus explained.

The second horizontal shelf on the south side contains different varieties of the "top rock," consisting of graphic pegmatite and granular pegmatite. The third horizontal shelf shows the mineral aggregates of the middle part or "pay streak," which yields on decomposition the loose, friable material forming the gem pockets. This same shelf also shows examples of the banded "bottom rock."

The sloping shelf on the south side contains large specimens of the different varieties of the pegmatite rock, including granular, graphic, and banded pegmatites. Several of these larger specimens have been sawed and polished and are well adapted for use as an ornamental stone, especially when cut obliquely so as to form wavy lines and circular effects resembling bird's-eye wood. One specimen in particular consists of a large section of the entire pegmatite dike and shows the aggregate of lithium minerals in the upper portion or "top rock," the granular pegmatite of the middle portion, and the banded "bottom rock."

The sloping shelf on the north side of the case illustrates the mineral contents of the gem pockets. A sample of the gem-bearing clay or pocket material is first shown, below which is an equal amount of similar gem clay separated into its constituent minerals; thus the relative proportions of the gem tourmaline, the clay washed into the pocket from the decomposed gabbro country rock, and the various minerals associated with the gem tourmaline are exhibited. For example, the pocket material from the Tourmaline King mine, at Pala, shows much lepidolite, orthoclase, clay, and gem tourmaline (pink and green), and smaller amounts of muscovite and quartz. Similar gem-bearing clay from the Tourmaline Queen mine, at Pala, shows in addition to much pink tourmaline, large amounts of clay, quartz, albite, and cookeite, but practically no orthoclase. A gem pocket from the Ed. Fletcher, jr., mine, at Pala, shows in addition to much pink tourmaline, clay, and albite, a considerable amount of lepidolite, with only a little orthoclase. A gem pocket from the Pala Chief mine, at Pala, shows considerable gem kunzite, with lepidolite, quartz, clay, cookeite, and orthoclase, and smaller amounts

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of albite and muscovite. A similar pocket from the Caterina mine at Pala, shows only spodumene, pink clay, and quartz. The exhibit also includes a pocket containing an abundance of small blue tourmalines; a small pocket from the Tourmaline King mine, very rich in gem tourmalines; and several pockets free from any gem stones. Such pockets are known by the miners as "dead ones."

On this same sloping shelf are shown also several large specimens of the minerals associated with the gem pockets. Among these minerals may be noted a fine example of orbicular muscovite, an altered perthite (felspar) crystal, a large amblygonite crystal, and several speciments of spodumene (kunzite) in the matrix. These kunzite specimens are very difficult to collect, as in general the matrix of the kunzite is so friable that it breaks to pieces when it is taken out of the mine.

The three horizontal shelves above the sloping shelf on the north side of the case contain well-developed and well-crystallized specimens of the different minerals found in the gem-pocket zone of the pegmatite dikes. Among these minerals may be noted in particular a good series of the various forms of lepidolite (including several well-crystallized specimens), crystals of muscovite, fine tourmaline crystals, albite and orthoclase in well-developed crystals, pink beryl, stilbite, cassiterite, a large crystal of lithiophilite, bismuth, bismuthite, bismuthosphaerite, purpurite, hematite and pyrite, apatite, pucherite, topaz, manganotantalite, a fine example of clear pink kunzite in the matrix, and the phosphate minerals first found in this locality, namely, palaite, salmonsite, and sicklerite.

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COAL.

By C. E. LESHER.

INTRODUCTION.

GENERAL STATEMENT.

The statistics presented in this report cover the calendar year 1916 and are of interest not only because they are the latest complete figures available but because they constitute a basis for current estimates. The corresponding report for the year 1915 was prepared in two parts—A, containing statistics of production, and B, containing statistics of distribution and consumption. The extra work involved in the preparation of the report on distribution and consumption, with the meager clerical force available, delayed for about six weeks the collection and compilation of the figures in that report and precluded any attempt to compile comparable statistics on distribution and consumption for 1916.

An important change in the matter of reporting the values of the coal at the mine was begun with the collection of the data for 1916. In previous years operators were asked merely to give the total value at the mine of all coal mined. For 1916 they were asked to report separately the value of shipments, coal for local trade, mine fuel, and coal coked at the mine, and, for Pennsylvania anthracite, to report the values of the different sizes produced. The obvious disadvantage of showing only general averages covering dissimilar products is thus in part overcome.

ACKNOWLEDGMENTS.

The writer wishes to express his very hearty appreciation of the good will and cooperation of the corporations, firms, and individuals engaged in the coal industry, whose voluntary reports of operations have made possible the complete statistics presented. The cooperation of the officials of 104 railroads in furnishing monthly statements of movements of coal and coke and other data, and the assistance rendered by the chief mine inspectors of Alabama, Pennsylvania, and West Virginia, the chief of the department of mines of Kentucky, and the officials of the Ohio industrial commission, as well as by secretaries of boards of trade and other local authorities, are gratefully acknowledged. The State geologists of Alabama, Illinois, Iowa, Maryland, Oregon, Virginia, and Washington cooperated in the collection of the reports from the coal operators. Special credit is due to Miss Lida Mann and Mrs. H. L. Bennit, of the United States Geological Survey, for efficient clerical assistance.

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The great delay in the publication of this report has been in no wise due to more than ordinary difficulty in the collection and compilation of the statistics, but rather to the fact that the writer has been engaged in what has seemed to be more urgent work, first with the Committee on Coal Production of the Council of National Defense and later with the United States Fuel Administration.

UNIT OF MEASUREMENT.

The standard unit of measurement adopted for this report is the net ton of 2,000 pounds, although for certain uses the gross ton is employed. Pennsylvania anthracite is mined and sold by the gross ton of 2,240 pounds, and that unit is used in the part of the report dealing with that product. In all other statistics of production reported to the Geological Survey in gross tons the figures have been reduced to net tons, and, unless otherwise expressly stated, the net ton is meant where any statement of quantity is made in the text.

PRODUCTION.

Summary of statistics of coal produced in 1915 and 1916.

	1915		1916	
	Quantity (net tons).	Value.	Quantity (net tons).	Value.
Bituminous coal and lignite	442,624,426	$502,087,688	502,519,682	$665,116,077
Pennsylvania anthracite	88,995,061	184,653,498	87,578,493	202,009,561
	531,619,487	686,691,186	590,098,175	867,125,638

	Increase or decrease, 1916.			
	Quantity.		Value.*	
	Net tons.	Per cent.	Dollars.	Per cent.
Bituminous coal and lignite	+59,895,256	+13.5	+163,078,389	+32.5
Pennsylvania anthracite	− 1,416,568	− 1.6	+ 17,356,063	+ 9.4
	+58,478,688	+11.0	+180,434,452	+26.3

The bituminous coal industry began the year 1916 by establishing a new high record in the rate of production, and in January, February, and March the production was greater than in any similar period in the history of the country. Production in that period was in excess of consumption, many industries, especially the railroads, having stored coal in anticipation of a cessation of mining in April, pending the adjustment of a new wage scale in the union fields of the central competitive States. In that period there was no general complaint of lack of cars or of labor, and prices were in general normal. The shortage of railroad cars in western Pennsylvania that developed in the last quarter of 1915 continued throughout the early part of 1916 and caused a local shortage of coal, which in turn resulted in comparatively small increases in the current quotations

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on free coal in the immediate and surrounding producing districts. It is estimated that not less than 10,000,000 tons of bituminous coal were put in storage during the winter months of 1915–16. Demand for coal in April was therefore subnormal, and, although there was no general cessation of mining, production was curtailed, the industries with coal in storage utilized their excess supplies, and prices, where they had been high, dropped to the spring and summer levels.

Throughout May, June, and July production kept pace with demand and prices continued steady. Throughout July, August, and September the rate of production tended steadily upward, in response to a quiet, uniform increase in demand, but without noticeable effect on prices until late in September. In October it became evident that production might not, in the ensuing months, be sufficient to meet requirements, especially were a shortage of cars to develop. A rush of buying followed, a real difficulty arose in getting coal cars, and in the first half of November prices for free coal rose to three and four times those which prevailed earlier in the year.

Stimulated by these prices production rose to high levels in November and December, notwithstanding the shortage of cars and the congestion of the railroads in the Eastern States.

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Coal produced in the United States in 1915.

State.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Alabama	12,222,496	389,239	535,340	1,780,872	14,927,937	$19,066,043	$1.28	22,591	223
Alaska	.....	1,400	.....	.....	1,400	3,300	2.36	.....	.....
Arkansas	1,543,671	46,260	62,175	.....	1,652,106	2,950,456	1.79	3,751	149
California, Idaho, and Nevada	2,488	9,715	300	.....	12,503	32,054	2.56	36	265
Colorado	7,023,820	291,243	294,571	1,015,346	8,624,980	13,599,264	1.58	12,372	194
Georgia	90,523	1,396	7,200	35,377	134,496	231,861	1.72	368	197
Illinois	54,826,393	2,470,114	1,533,069	.....	58,829,576	64,622,471	1.10	75,610	179
Indiana	16,033,039	547,761	425,352	.....	17,006,152	18,637,476	1.10	22,777	179
Iowa	6,963,696	502,286	148,159	.....	7,614,143	13,577,608	1.78	15,549	220
Kansas	6,535,872	104,531	184,071	.....	6,824,474	11,360,630	1.66	13,260	184
Kentucky	19,821,392	586,864	495,313	458,105	21,361,674	21,494,008	1.01	27,960	186
Maryland	4,076,981	38,908	64,588	.....	4,180,477	5,330,845	1.28	5,664	242
Michigan	1,077,945	42,474	35,719	.....	1,156,138	2,372,797	2.05	2,569	196
Missouri	3,335,527	391,975	84,091	.....	3,811,593	6,595,918	1.73	9,173	186
Montana	2,561,239	105,924	122,592	.....	2,789,755	4,526,509	1.62	3,158	201
New Mexico	3,021,082	33,277	28,868	734,713	3,817,940	5,481,361	1.44	4,205	262
North Dakota	358,622	151,957	17,499	.....	528,078	766,072	1.45	590	219
Ohio	20,051,585	1,916,188	465,701	1,217	22,434,691	24,207,075	1.08	40,053	142
Oklahoma	3,406,533	39,482	247,565	.....	3,693,580	7,435,906	2.01	8,457	167
Oregon	20,142	2,272	6,817	.....	29,231	111,240	2.84	151	206
Pennsylvania (bituminous)	119,176,343	3,231,909	3,048,515	32,498,370	157,955,137	167,419,705	1.06	174,598	226
South Dakota	3,794	6,799	.....	.....	10,593	16,384	1.55	35	155
Tennessee	5,175,592	71,071	167,560	316,138	5,730,361	6,479,916	1.13	8,948	220
Texas	2,016,286	13,266	59,356	.....	2,088,908	3,445,487	1.65	5,087	233
Utah	2,302,800	47,224	104,304	654,387	3,108,715	4,916,916	1.58	3,564	206
Virginia	6,948,235	52,210	135,799	956,352	8,122,596	7,962,934	.98	8,959	225
Washington	2,089,051	64,707	126,047	149,290	2,429,095	5,276,299	2.17	4,850	169
West Virginia	72,956,241	1,091,371	1,141,178	1,996,279	77,184,069	74,561,349	.97	75,882	208
Wyoming	6,225,211	71,885	256,932	.....	6,554,028	9,555,804	1.46	7,244	201
Total bituminous	379,876,591	12,353,708	9,798,681	40,595,446	442,624,426	502,037,688	1.13	557,456	203
Pennsylvania anthracite	76,906,431	2,092,086	9,996,544	.....	88,995,061	184,653,498	2.07	176,552	220
Grand total	456,783,022	14,445,794	19,795,225	40,595,446	531,619,487	686,691,186	1.29	734,008	209

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Coal produced in the United States in 1916.

State.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Alabama	14,422,356	390,682	587,211	2,685,948	18,086,197	$24,859,831	$1.37	25,308	262
Alaska	7,913	5,098	62	.....	13,073	52,317	4.00	83	179
Arkansas	1,881,105	44,254	69,556	.....	1,994,915	3,836,845	1.92	3,772	184
California and Idaho	1,593	4,647	1,000	.....	7,240	15,367	2.12	18	188
Colorado	8,057,820	396,376	271,484	1,758,557	10,484,237	16,964,104	1.62	13,104	223
Georgia	76,954	1,672	7,200	87,728	173,554	310,093	1.79	411	280
Illinois	61,486,342	3,086,157	1,622,837	.....	66,195,336	82,457,954	1.25	75,538	198
Indiana	18,839,568	790,345	463,615	.....	20,093,528	25,506,246	1.27	23,965	187
Iowa	6,521,770	591,717	147,313	.....	7,260,800	13,530,383	1.86	14,443	202
Kansas	6,577,064	145,053	159,338	.....	6,881,455	12,252,723	1.78	12,132	204
Kentucky	23,473,421	783,268	484,741	652,567	25,393,997	30,193,047	1.19	31,222	208
Maryland	4,320,720	74,113	65,213	.....	4,460,046	6,947,623	1.56	5,633	256
Michigan	1,097,107	51,770	31,483	.....	1,180,360	2,653,182	2.25	2,535	216
Missouri	4,219,414	435,368	88,364	.....	4,742,146	9,044,505	1.91	9,654	207
Montana	3,350,665	142,130	139,732	.....	3,632,527	6,286,197	1.73	3,781	244
New Mexico	2,873,313	50,421	25,194	844,083	3,793,011	5,580,369	1.47	4,522	292
North Dakota	440,752	173,936	20,224	.....	634,912	946,092	1.49	714	244
Ohio	31,995,913	2,123,678	607,908	720	34,728,219	46,150,907	1.33	41,394	197
Oklahoma	3,395,363	34,000	178,648	.....	3,608,011	7,525,427	2.09	7,800	178
Oregon	28,373	7,482	6,737	.....	42,592	113,976	2.68	106	236
Pennsylvania (bituminous)	123,181,649	4,212,186	3,375,483	39,526,106	170,295,424	221,685,175	1.30	168,212	259
South Dakota	891	7,995	.....	.....	8,886	18,021	2.03	38	145
Tennessee	5,266,733	99,289	174,093	597,334	6,137,449	7,522,445	1.23	9,211	230
Texas	1,939,947	17,670	29,886	.....	1,987,503	3,092,663	1.56	4,481	218
Utah	2,686,880	65,260	78,435	736,853	3,567,428	5,795,944	1.62	3,129	228
Virginia	7,513,641	156,730	113,376	1,923,727	9,707,474	10,261,424	1.06	9,777	273
Washington	2,701,031	75,954	124,740	186,863	3,088,588	6,907,428	2.27	4,797	217
West Virginia	79,760,681	1,768,827	1,171,205	3,759,414	86,460,127	102,366,092	1.18	78,067	237
Wyoming	7,547,706	96,055	266,886	.....	7,910,647	12,239,707	1.55	7,255	248
Total bituminous	423,666,685	15,832,633	10,310,464	52,709,900	502,519,682	665,116,077	1.32	561,102	230
Pennsylvania (anthracite)	75,601,526	2,216,067	9,760,880	.....	87,578,493	202,009,561	2.30	159,869	253
Grand total	499,268,211	18,048,720	20,071,344	52,709,900	590,098,175	867,125,638	1.47	720,971	235

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Value of coal produced in the United States in 1916.

State.	Loaded at mines for shipment.	Average value per ton.	Sold to local trade and used by employees.	Average value per ton.	Used at mines for steam and heat.	Average value per ton.	Made into coke at mines.	Average value per ton.	Total value.	Average value per ton.
Alabama	$20,015,046	$1.39	$579,342	$1.48	$705,879	$1.20	$3,559,564	$1.33	$24,859,831	$1.37
Alaska	37,159	4.70	14,832	2.91	326	5.26	.....	.....	52,317	4.00
Arkansas	3,637,973	1.93	102,545	2.32	96,327	1.38	.....	.....	3,836,845	1.92
California and Idaho	3,234	2.03	11,133	2.40	1,000	1.00	.....	.....	15,367	2.12
Colorado	13,657,844	1.69	660,178	1.67	313,616	1.16	2,332,466	1.33	16,964,104	1.62
Georgia	141,840	1.84	1,773	1.06	8,640	1.20	157,840	1.80	310,093	1.79
Illinois	75,566,086	1.23	5,316,399	1.72	1,575,469	.97	.....	.....	82,457,954	1.25
Indiana	23,867,222	1.27	1,158,427	1.47	480,597	1.04	.....	.....	25,506,246	1.27
Iowa	12,062,465	1.85	1,311,111	2.22	156,807	1.06	.....	.....	13,530,383	1.86
Kansas	11,734,804	1.78	305,105	2.10	212,814	1.34	.....	.....	12,252,723	1.78
Kentucky	28,135,151	1.20	971,268	1.24	459,812	.95	626,816	.96	30,193,047	1.19
Maryland	6,730,068	1.56	112,794	1.52	104,761	1.61	.....	.....	6,947,623	1.56
Michigan	2,442,102	2.23	154,117	2.98	56,963	1.81	.....	.....	2,653,182	2.25
Missouri	7,929,340	1.88	987,207	2.26	127,958	1.47	.....	.....	9,044,505	1.91
Montana	5,841,429	1.74	331,327	2.33	113,441	.81	.....	.....	6,286,197	1.73
New Mexico	4,552,160	1.58	78,718	1.56	30,793	1.22	918,698	1.09	5,580,369	1.47
North Dakota	655,545	1.49	270,095	1.55	20,442	1.01	.....	.....	946,082	1.49
Ohio	42,571,318	1.33	2,905,746	1.37	673,195	1.11	648	.90	46,150,907	1.33
Oklahoma	7,164,358	2.11	83,088	2.44	277,981	1.56	.....	.....	7,525,427	2.09
Oregon	87,702	3.09	19,216	2.57	7,058	1.05	.....	.....	113,976	2.63
Pennsylvania (bituminous)	163,491,695	1.33	5,833,879	1.39	3,927,220	1.16	48,432,381	1.23	221,685,175	1.30
South Dakota	1,782	2.00	16,239	2.03	.....	.....	.....	.....	18,021	2.03
Tennessee	6,559,072	1.25	133,929	1.35	177,099	1.02	652,345	1.09	7,522,445	1.23
Texas	3,022,862	1.56	34,811	1.97	34,990	1.17	.....	.....	3,092,663	1.56
Utah	5,650,542	1.65	107,771	1.65	37,631	.48	(a)	.....	5,795,944	1.62
Virginia	8,348,668	1.11	175,286	1.12	122,107	1.08	1,615,363	.84	10,261,424	1.06
Washington	6,158,817	2.28	166,537	2.19	179,706	1.44	402,868	2.94	6,907,428	2.27
West Virginia	95,745,695	1.20	2,115,269	1.20	1,170,388	1.00	3,334,740	.89	102,366,092	1.18
Wyoming	11,872,979	1.57	152,414	1.59	214,314	.80	.....	.....	12,239,707	1.55
Total bituminous	567,684,458	1.34	24,110,556	1.52	11,287,334	1.09	62,033,729	1.18	665,116,077	1.32
Pennsylvania (anthracite)	193,336,887	2.56	4,619,356	2.08	4,053,318	.42	.....	.....	202,009,561	2.30
Grand total	761,021,345	.....	28,729,912	.....	15,340,652	.....	62,033,729	.....	867,125,638	.....

a Value of coke included in shipments.

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Coal produced in the United States, 1912–1916, and increase or decrease in 1916.

State.	1912		1913		1914		1915	
	Quantity (net tons).	Value.	Quantity (net tons).	Value.	Quantity (net tons).	Value.	Quantity (net tons).	Value.
Alabama	16,100,600	$20,829,252	17,678,522	$23,083,724	15,593,422	$20,849,919	14,927,937	$19,066,043
Arkansas	2,100,819	3,582,789	2,234,107	3,923,701	1,836,540	3,158,168	1,652,106	2,950,456
California and Alaska	11,333	26,441	26,911	95,173	[a] 13,974	[a] 39,821	[a] 13,903	[a] 35,354
Colorado	10,977,824	16,345,336	9,232,510	14,035,090	8,170,559	13,601,718	8,624,980	13,599,264
Georgia	227,703	338,926	255,626	361,319	166,498	239,462	134,496	231,861
Idaho and Nevada	[b] 2,964	[b] 9,313	2,177	5,285	(c)	(c)	(c)	(c)
Illinois	59,885,226	70,294,338	61,618,744	70,313,605	57,589,197	64,693,529	58,829,576	64,622,471
Indiana	15,285,718	17,480,546	17,165,671	19,001,881	16,641,132	18,290,928	17,006,152	18,637,476
Iowa	7,289,529	13,152,088	7,525,936	13,496,710	7,451,022	13,364,070	7,614,143	13,577,608
Kansas	6,966,182	11,324,130	7,202,210	12,036,292	6,860,988	11,238,253	6,824,474	11,360,630
Kentucky	16,490,521	16,854,207	19,616,600	20,516,749	20,382,763	20,852,463	21,361,674	21,494,008
Maryland	4,964,038	5,839,079	4,779,839	5,927,046	4,133,547	5,234,796	4,180,477	5,330,845
Michigan	1,206,230	2,396,451	1,231,786	2,455,227	1,283,030	2,559,786	1,156,138	2,372,797
Missouri	4,339,856	7,633,864	4,318,125	7,468,308	3,935,980	6,802,325	3,811,593	6,595,918
Montana	3,048,495	5,558,195	3,240,973	5,653,539	2,805,173	4,913,191	2,789,755	4,526,509
New Mexico	3,536,824	5,037,051	3,708,806	5,401,260	3,877,689	6,230,871	3,817,940	5,481,361
North Dakota	499,480	765,105	495,320	750,652	506,685	771,379	528,078	766,972
Ohio	34,528,727	37,063,363	36,200,527	39,948,058	18,843,115	21,250,642	22,434,691	24,207,075
Oklahoma	3,675,418	7,867,331	4,165,770	8,542,748	3,988,613	8,204,015	3,693,580	7,435,906
Oregon	41,637	108,276	46,063	116,724	51,558	143,556	39,231	111,240
Pennsylvania (bituminous)	161,865,488	169,370,497	173,781,217	193,039,806	147,983,294	159,006,296	157,955,137	167,419,705
South Dakota			10,540	20,648	11,850	20,456	10,593	16,384
Tennessee	6,473,228	7,379,903	6,860,184	7,839,721	5,943,258	6,776,573	5,730,361	6,479,916
Texas	2,188,612	3,655,744	2,429,144	4,288,920	2,323,773	3,922,459	2,088,908	3,445,487
Utah	3,016,149	5,046,451	3,254,828	5,384,127	3,103,036	4,935,454	3,108,715	4,916,916
Virginia	7,846,638	7,518,576	8,828,068	8,952,653	7,959,535	8,032,448	8,122,596	7,962,934
Washington	3,360,932	8,042,871	3,877,891	9,243,137	3,064,820	6,751,511	2,429,095	5,276,299
West Virginia	66,786,687	62,792,234	71,254,136	71,822,804	71,707,626	71,391,408	77,184,069	74,561,349
Wyoming	7,368,124	11,648,068	7,393,066	11,510,045	6,475,293	10,033,747	6,554,028	9,555,804
Total bituminous	450,104,982	517,983,445	478,435,297	565,234,952	422,703,970	493,309,244	442,624,426	502,037,688
Pennsylvania (anthracite)	84,361,598	177,622,626	91,524,922	195,181,127	90,821,507	188,181,399	88,995,061	184,653,498
Grand total	534,466,580	695,606,071	569,960,219	760,416,079	513,525,477	681,490,643	531,619,487	686,691,186

[a] California, Idaho, and Nevada in 1914; California, Alaska, Idaho, and Nevada in 1915; and California, Alaska, and Idaho in 1916.
[b] Idaho only.
[c] Included with California.

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Coal produced in the United States, 1912–1916, and increase or decrease in 1916.—Continued.

State.	1916.		Increase or decrease, 1916.			
	Quantity (net tons).	Value.	Quantity.		Value.	
			Net tons.	Per cent.	Dollars.	Per cent.
Alabama	18,086,197	$24,859,831	+ 3,158,260	+21.1	+ $5,793,788	+30.4
Arkansas	1,994,915	3,836,845	+ 342,809	+20.7	+ 886,389	+30.0
California and Alaska	[a] 20,313	[a] 67,684	+ 6,410	+34.2	+ 32,330	+91.4
Colorado	10,484,237	16,964,104	+ 1,859,257	+21.6	+ 3,364,840	+24.7
Georgia	173,554	310,093	+ 39,058	+29.0	+ 78,232	+33.7
Idaho and Nevada	[b]	[b]	[b]	[b]	[b]	[b]
Illinois	66,195,336	82,457,954	+ 7,365,760	+12.5	+ 17,835,483	+27.6
Indiana	20,093,528	25,506,246	+ 3,087,376	+18.2	+ 6,868,770	+36.8
Iowa	7,260,800	13,530,383	− 353,343	− 4.6	− 47,225	− .3
Kansas	6,881,455	12,252,723	+ 56,961	+ .8	+ 892,093	+ 9.3
Kentucky	25,393,997	30,193,047	+ 4,032,323	+18.9	+ 8,699,039	+40.5
Maryland	4,460,046	6,947,623	+ 279,569	+ 6.7	+ 1,616,778	+30.3
Michigan	1,180,360	2,653,182	+ 24,222	+ 2.1	+ 280,395	+11.8
Missouri	4,742,146	9,044,505	+ 930,553	+24.4	+ 2,448,587	+37.1
Montana	3,632,527	6,286,197	+ 842,772	+30.2	+ 1,759,688	+38.9
New Mexico	3,793,011	5,580,369	− 24,929	− .7	+ 99,008	+ 1.8
North Dakota	634,912	946,082	+ 106,834	+20.2	+ 180,010	+23.5
Ohio	34,728,219	46,150,907	+12,293,528	+54.8	+ 21,943,832	+90.7
Oklahoma	3,608,011	7,525,427	− 85,569	− 2.3	+ 89,521	+ 1.2
Oregon	42,392	113,976	+ 3,361	+ 8.6	+ 2,736	+ 2.5
Pennsylvania (bituminous)	170,295,424	221,685,175	+12,340,287	+ 7.8	+ 54,265,470	+32.4
South Dakota	8,886	18,021	− 1,707	−16.1	+ 1,637	+10.1
Tennessee	6,137,449	7,522,445	+ 407,088	+ 7.1	+ 1,042,529	+16.0
Texas	1,987,508	3,092,663	− 101,405	− 4.9	− 352,824	−10.2
Utah	3,567,428	5,795,944	+ 458,713	+14.8	+ 879,028	+17.9
Virginia	9,707,474	10,261,424	+ 1,584,878	+19.5	+ 2,298,490	+28.9
Washington	3,088,588	6,907,428	+ 609,498	+25.1	+ 1,631,129	+30.9
West Virginia	86,460,127	102,366,092	+ 9,276,058	+12.0	+ 27,804,743	+37.3
Wyoming	7,910,647	12,239,707	+ 1,356,619	+20.7	+ 2,683,908	+28.1
Total bituminous	502,519,682	665,116,077	+59,895,256	+13.5	+163,078,389	+32.5
Pennsylvania (anthracite)	87,578,493	202,009,561	− 1,416,568	− 1.6	+ 17,356,063	+ 9.4
Grand total	590,098,175	867,125,638	+58,478,688	+11.0	+180,434,452	+26.3

[a] California, Idaho, and Nevada in 1914; California, Alaska, Idaho, and Nevada in 1915; and California, Alaska, and Idaho in 1916. [b] Included with California.

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Coal produced in the United States from 1807 to the end of 1916, in net tons.

Year.	Pennsylvania anthracite.	Bituminous.	Total.	Year.	Pennsylvania anthracite.	Bituminous.	Total.
1807–1820	12,000	3,000	15,000	1871.....	19,342,057	27,543,023	46,885,080
				1872.....	24,233,166	27,220,233	51,453,399
1821.....	1,322	.....	1,322	1873.....	26,152,337	31,449,643	57,602,480
1822.....	4,583	54,000	58,583	1874.....	24,818,790	27,787,130	52,606,920
1823.....	8,563	60,000	68,563	1875.....	22,485,766	29,862,554	52,348,320
1824.....	13,685	67,040	80,725				
1825.....	42,988	75,000	117,988	1876.....	22,793,245	30,486,755	53,280,000
				1877.....	25,660,316	34,841,444	60,501,760
1826.....	59,194	88,720	147,914	1878.....	21,689,682	36,245,918	57,935,600
1827.....	78,151	94,000	172,151	1879.....	30,207,793	37,898,006	68,105,799
1828.....	95,500	100,408	195,908	1880.....	28,649,812	42,831,758	71,481,570
1829.....	138,086	102,000	240,086				
1830.....	215,272	104,800	320,072	1881.....	31,920,018	53,961,012	85,881,030
				1882.....	35,121,256	68,429,933	103,551,189
1831.....	217,842	120,100	337,942	1883.....	38,456,845	77,250,680	115,707,525
1832.....	447,550	146,500	594,050	1884.....	37,156,847	82,998,704	120,155,551
1833.....	600,907	133,750	734,657	1885.....	38,335,974	72,824,321	111,160,295
1834.....	464,015	136,500	600,515				
1835.....	690,854	134,000	824,854	1886.....	39,035,446	74,644,981	113,680,427
				1887.....	42,088,197	88,562,314	130,650,511
1836.....	842,832	142,000	984,832	1888.....	46,619,564	102,040,093	148,659,657
1837.....	1,071,151	182,500	1,253,651	1889.....	45,546,970	95,682,543	141,229,513
1838.....	910,075	445,452	1,355,527	1890.....	46,468,641	111,302,322	157,770,963
1839.....	1,008,322	552,038	1,560,360				
1840.....	967,108	1,102,931	2,070,039	1891.....	50,665,431	117,901,238	168,566,669
				1892.....	52,472,504	126,856,567	179,329,071
1841.....	1,182,441	1,108,700	2,291,141	1893.....	53,967,543	128,385,231	182,352,774
1842.....	1,365,563	1,244,494	2,610,057	1894.....	51,921,121	118,820,405	170,741,526
1843.....	1,556,753	1,504,121	3,060,874	1895.....	57,999,337	135,118,193	193,117,530
1844.....	2,009,207	1,672,045	3,681,252				
1845.....	2,480,082	1,829,872	4,309,904	1896.....	54,346,081	137,640,276	191,986,357
				1897.....	52,611,680	147,617,519	200,229,199
1846.....	2,887,815	1,977,707	4,865,522	1898.....	53,382,644	166,593,623	219,976,267
1847.....	3,551,005	1,735,062	5,286,067	1899.....	60,418,005	193,323,187	253,741,192
1848.....	3,805,942	1,968,032	5,773,974	1900.....	57,367,915	212,316,112	269,684,027
1849.....	3,995,334	2,453,497	6,448,831				
1850.....	4,138,164	2,880,017	7,018,181	1901.....	67,471,667	225,828,149	293,299,816
				1902.....	41,373,595	260,216,844	301,590,439
1851.....	5,481,065	3,253,460	8,734,525	1903.....	74,607,068	282,749,348	357,356,416
1852.....	6,151,957	3,664,707	9,816,664	1904.....	73,156,709	278,659,689	351,816,398
1853.....	6,400,426	4,169,862	10,570,288	1905.....	77,659,850	315,062,785	392,722,635
1854.....	7,394,875	4,582,227	11,977,102				
1855.....	8,141,754	4,784,919	12,926,673	1906.....	71,282,411	342,874,867	414,157,278
				1907.....	85,604,312	394,759,112	480,363,424
1856.....	8,534,779	5,012,146	13,546,925	1908.....	83,268,754	332,573,944	415,842,698
1857.....	8,186,567	5,153,622	13,340,189	1909.....	81,070,359	379,744,257	460,814,616
1858.....	8,426,102	5,548,376	13,974,478	1910.....	84,485,236	417,111,142	501,596,378
1859.....	9,619,771	6,013,404	15,633,175				
1860.....	8,115,842	6,494,200	14,610,042	1911.....	90,464,067	405,907,059	496,371,126
				1912.....	84,361,598	450,104,982	534,466,580
1861.....	9,799,654	6,688,358	16,488,012	1913.....	91,524,922	478,435,297	569,960,219
1862.....	9,996,110	7,790,725	17,485,835	1914.....	90,821,507	422,703,970	513,525,477
1863.....	11,785,320	9,533,742	21,319,062	1915.....	88,995,061	442,624,426	531,619,487
1864.....	12,538,649	11,066,474	23,605,123	1916.....	87,578,493	502,519,682	590,098,175
1865.....	11,891,746	11,900,427	23,792,173				
					2,714,091,071	8,765,312,005	11,479,403,076
1866.....	15,651,183	13,352,400	29,003,583				
1867.....	16,002,109	14,722,313	30,724,422				
1868.....	17,003,405	15,858,555	32,861,960				
1869.....	17,083,134	15,821,226	32,904,360				
1870.....	15,664,275	17,371,305	33,035,580				

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Average value per net ton of coal at the mines since 1908.

State.	1908	1909	1910	1911	1912	1913	1914	1915	1916	Advance or decline in 1916.
Alabama	$1.26	$1.19	$1.26	$1.27	$1.29	$1.31	$1.34	$1.28	$1.37	+$0.09
Alaska									4.00	(a)
Arkansas	1.68	1.48	1.56	1.61	1.71	1.76	1.72	1.79	1.92	+ .13
California	b 3.19	2.21	b 2.74	b 2.00	b 2.33	b 3.54	c 2.85	b c 2.54	b c 2.12	− .42
Colorado	1.41	1.33	1.42	1.45	1.49	1.52	1.66	1.58	1.62	+ .04
Georgia	1.38	1.41	1.46	d 1.49	d 1.49	1.41	e 1.44	1.72	1.79	+ .07
Idaho	4.02	4.27	3.92	f 2.68	f 3.14	2.43	(c)	(c)	(b)	(b)
Illinois	1.05	1.05	1.14	1.11	1.17	1.14	1.12	1.10	1.25	+ .15
Indiana	1.06	1.02	1.13	1.08	1.14	1.11	1.10	1.10	1.27	+ .17
Iowa	1.63	1.65	1.75	1.73	1.80	1.79	1.79	1.78	1.86	+ .08
Kansas	1.49	1.44	1.61	1.53	1.62	1.67	1.64	1.66	1.78	+ .12
Kentucky	1.01	.94	.99	.99	1.02	1.05	1.02	1.01	1.19	+ .18
Maryland	1.17	1.11	1.12	1.11	1.18	1.24	1.27	1.28	1.56	+ .28
Michigan	1.81	1.79	1.91	1.78	1.99	1.99	1.99	2.05	2.25	+ .20
Missouri	1.64	1.65	1.79	1.72	1.76	1.73	1.73	1.73	1.91	+ .18
Montana	1.96	1.97	1.82	1.79	1.82	1.74	1.75	1.62	1.73	+ .11
New Mexico	1.37	1.29	1.39	1.44	1.42	1.46	1.61	1.44	1.47	+ .03
North Dakota	1.63	1.56	1.49	1.43	1.53	1.52	1.52	1.45	1.49	+ .04
Ohio	1.06	.99	1.05	1.03	1.07	1.10	1.13	1.08	1.33	+ .25
Oklahoma	2.03	2.00	2.22	2.05	2.14	2.05	2.06	2.01	2.09	+ .08
Oregon	2.74	2.69	3.48	2.32	2.60	2.53	2.78	2.84	2.68	− .16
Pennsylvania (bituminous)	1.01	.94	1.02	1.01	1.05	1.11	1.07	1.06	1.30	+ .24
South Dakota						1.96	1.73	1.55	2.03	+ .48
Tennessee	1.15	1.09	1.11	1.12	1.14	1.14	1.14	1.13	1.23	+ .10
Texas	1.80	1.72	1.67	1.66	1.67	1.77	1.69	1.65	1.56	− .09
Utah	1.69	1.66	1.68	1.69	1.67	1.65	1.59	1.58	1.62	+ .04
Virginia	.91	.89	.90	.91	.96	1.01	1.01	.98	1.06	+ .08
Washington	2.21	2.54	2.50	2.29	2.39	2.38	2.20	2.17	2.27	+ .10
West Virginia	.95	.86	.92	.90	.94	1.01	.99	.97	1.18	+ .21
Wyoming	1.62	1.55	1.55	1.56	1.58	1.56	1.55	1.46	1.55	+ .09
Total bituminous	1.12	1.07	1.12	1.11	1.15	1.18	1.17	1.13	1.32	+ .19
Pennsylvania anthracite	1.90	1.84	1.90	1.94	2.11	2.13	2.07	2.07	2.30	+ .23

a Included with in California previous years.
b Includes Alaska.
c California includes Idaho and Nevada in 1914 and 1915; Idaho in 1916.
d Includes North Carolina.
e Average for total output including refuse from washery. The average excluding refuse was $1.71.
f Includes Nevada.

Average value per net ton of coal at the mines in the United States for 37 years.

Year.	Anthracite.	Bituminous.	Year.	Anthracite.	Bituminous.
1880	$1.47	$1.25	1899	$1.46	$0.87
1881	2.01	1.12	1900	1.49	1.04
1882	2.01	1.12	1901	1.67	1.05
1883	2.01	1.07	1902	1.84	1.12
1884	1.79	.94	1903	2.04	1.24
1885	2.00	1.13	1904	1.90	1.10
1886	1.95	1.05	1905	1.83	1.06
1887	2.01	1.11	1906	1.85	1.11
1888	1.91	1.00	1907	1.91	1.14
1889	1.44	.99	1908	1.90	1.12
1890	1.43	.99	1909	1.84	1.07
1891	1.46	.99	1910	1.90	1.12
1892	1.57	.99	1911	1.94	1.11
1893	1.59	.96	1912	2.11	1.15
1894	1.51	.91	1913	2.13	1.18
1895	1.41	.86	1914	2.07	1.17
1896	1.50	.83	1915	2.07	1.13
1897	1.51	.81	1916	2.30	1.32
1898	1.41	.80			

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LABOR STATISTICS.

The record production of bituminous coal in 1916 was attained with only a slight increase in the number of men employed—557,456 in 1915 and 561,102 in 1916. These men, however, worked an average of 230 days in 1916 against 203 in 1915, and although the average daily output in tons per man decreased slightly—from 3.91 to 3.90—the average annual output increased from 794 tons to 896 tons, the highest on record. The number of men engaged in the production of anthracite decreased notably, from 176,552 in 1915 to 159,869 in 1916, but with an increase in the number of days worked from 230 to 253, the total output for the region was nearly maintained.

Shortage of labor, actual or impending, was reported in nearly all producing fields in the last half of the year. It is apparent from the data given in the following tables that this shortage was in many areas due to the increased demand for men rather than to an actual decrease in the number available.

In Alabama, Indiana, Kentucky, Ohio, and West Virginia the number of men employed in 1916 was equal to or greater than the number in 1915. In Pennsylvania, in both the anthracite and the bituminous coal regions, there was a substantial decrease in the number of men available.

Men employed in the coal mines of the United States in 1916.

State.	Underground.	Surface.	Total.
Alabama	21,453	3,855	25,308
Alaska	69	14	83
Arkansas	3,055	717	3,772
California	5	5	10
Colorado	10,456	2,648	13,104
Georgia	322	89	411
Idaho	6	2	8
Illinois	68,127	7,411	75,538
Indiana	20,992	2,973	23,965
Iowa	12,960	1,483	14,443
Kansas	10,325	1,807	12,132
Kentucky	26,501	4,721	31,222
Maryland	4,719	914	5,633
Michigan	2,124	411	2,535
Missouri	7,877	1,777	9,654
Montana	3,055	716	3,781
New Mexico	3,304	1,218	4,522
North Dakota	553	161	714
Ohio	36,680	4,714	41,394
Oklahoma	6,620	1,180	7,800
Oregon	78	28	106
Pennsylvania (bituminous)	139,186	29,026	168,212
South Dakota	26	12	38
Tennessee	7,661	1,550	9,211
Texas	3,901	580	4,481
Utah	2,397	732	3,129
Virginia	7,359	2,418	9,777
Washington	3,764	1,033	4,797
West Virginia	64,618	13,449	78,067
Wyoming	6,041	1,214	7,255
Total bituminous	474,244	86,858	561,102
Pennsylvania anthracite	116,705	43,164	159,869
Grand total	590,949	130,022	720,971

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Statistics of labor employed in coal mines of the United States, 1912–1916.

State.	1912		1913		1914		1915		1916	
	Number of days active.	Average number employed.	Number of days active.	Average number employed.	Number of days active.	Average number employed.	Number of days active.	Average number employed.	Number of days active.	Average number employed.
Alabama	245	22,613	255	24,552	226	24,042	223	22,591	262	25,308
Alaska	(a)	(a)	(a)	(a)	(b)	(b)	(b)	(b)	179	83
Arkansas	157	4,536	174	4,652	143	4,339	149	3,751	184	3,772
California	c 184	c 52	c 302	c 40	d 291	d 43	d 285	d 36	188	18
Colorado	227	13,000	229	11,990	244	10,098	194	12,372	223	13,104
Georgia	e 254	e 450	261	500	207	355	197	368	280	411
Idaho	f 253	f 20	f 183	f 12	(g)	(g)	(g)	(g)	(g)	(g)
Illinois	194	78,098	189	79,529	173	79,499	179	75,610	198	75,538
Indiana	182	21,651	190	22,235	168	23,175	179	22,777	187	23,965
Iowa	188	16,370	195	15,757	204	16,057	220	15,549	202	14,443
Kansas	202	11,646	197	12,479	192	12,448	184	12,260	204	12,132
Kentucky	201	24,304	212	26,332	187	28,764	186	27,990	208	31,222
Maryland	259	6,162	248	5,645	241	5,403	242	5,864	256	5,683
Michigan	183	3,113	188	3,305	201	2,800	196	2,569	216	2,535
Missouri	206	9,704	187	10,418	179	9,549	186	9,173	207	9,654
Montana	220	3,440	228	3,630	209	3,350	201	3,158	244	3,781
New Mexico	274	3,928	289	4,329	283	4,178	262	4,205	292	4,522
North Dakota	232	622	221	641	216	558	219	590	244	714
Ohio	201	45,527	206	45,815	108	45,401	142	40,053	197	41,394
Oklahoma	174	8,785	197	9,044	205	8,078	167	8,457	178	7,800
Oregon	239	222	283	203	266	190	206	151	236	108
Pennsylvania (bituminous)	252	165,144	267	172,196	214	184,201	226	174,593	259	168,212
South Dakota			137	48	152	47	155	35	145	38
Tennessee	234	10,209	241	11,238	220	10,116	220	8,948	239	9,211
Texas	230	5,127	253	5,101	237	4,635	233	5,087	218	4,481
Utah	285	3,328	273	4,158	210	4,112	208	3,564	228	3,129
Virginia	251	8,678	280	9,162	235	9,188	235	8,959	272	9,777
Washington	226	5,519	260	5,794	191	5,805	160	4,850	217	4,797
West Virginia	266	68,248	234	74,746	201	78,963	208	75,882	237	78,067
Wyoming	238	8,036	232	8,331	192	8,117	201	7,244	248	7,255
Total bituminous	223	548,632	232	571,882	195	583,506	208	557,456	230	561,102
Pennsylvania (anthracite)	231	174,030	257	175,745	245	179,679	230	176,552	253	159,869
Grand total	225	722,662	238	747,627	207	763,185	209	734,008	235	720,971

a Included with California.
b Number of men not reported.
c Includes Alaska.
d Includes Idaho and Nevada.
e Includes North Carolina.
f Includes Nevada.
g Included with California.

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Coal produced per man employed, 1890–1916.

Year.	Anthracite.				Bituminous.			
	Men employed.	Days worked.	Average tonnage per man per day.	Average tonnage per man per year.	Men employed.	Days worked.	Average tonnage per man per day.	Average tonnage per man per year.
1890	126,000	200	1.85	369	192,204	226	2.56	579
1891	126,350	203	1.98	401	205,803	223	2.57	573
1892	129,050	198	2.06	407	212,893	219	2.72	596
1893	132,944	197	2.06	406	220,365	204	2.73	557
1894	131,603	190	2.08	395	244,603	171	2.84	486
1895	142,917	196	2.07	406	239,962	194	2.90	563
1896	148,991	174	2.10	365	244,171	192	2.94	564
1897	149,884	150	2.34	351	247,817	196	3.04	596
1898	145,504	152	2.41	367	255,717	211	3.09	651
1899	139,608	173	2.50	433	271,027	234	3.05	713
1900	144,206	166	2.40	398	304,375	234	2.96	697
1901	145,309	196	2.37	464	340,235	225	2.94	664
1902	148,141	116	2.40	279	370,056	230	3.06	703
1903	150,483	206	2.41	496	415,777	225	3.02	680
1904	155,861	200	2.35	469	437,832	202	3.15	637
1905	165,406	215	2.18	470	460,639	211	3.24	684
1906	162,355	195	2.25	439	478,425	213	3.36	717
1907	167,234	220	2.33	512	513,258	234	3.29	769
1908	174,174	200	2.39	478	516,264	193	3.34	644
1910	169,497	229	2.17	498	555,533	217	3.46	751
1911	172,585	246	2.13	524	549,775	211	3.50	738
1912	174,030	231	2.10	485	548,632	223	3.68	820
1913	175,745	257	2.02	520	571,882	232	3.61	837
1914	179,679	245	2.06	505	583,506	195	3.71	724
1915	176,552	230	2.19	504	557,456	203	3.91	794
1916	159,869	253	2.16	548	561,102	230	3.90	896

Coal produced per man and average number of days per year in 1915 and 1916.

State.	1915			1916		
	Days worked.	Average tonnage.		Days worked.	Average tonnage.	
		Per year.	Per day.		Per year.	Per day.
Alabama	223	661	2.96	262	715	2.73
Arkansas	149	440	2.95	184	528	2.87
Colorado	194	697	3.60	233	800	3.43
Illinois	179	778	4.35	198	876	4.42
Indiana	179	747	4.17	187	838	4.48
Iowa	220	490	2.23	202	503	2.49
Kansas	184	515	2.80	204	567	2.78
Kentucky	186	764	4.11	208	813	3.91
Maryland	242	739	3.05	256	792	3.09
Michigan	198	450	2.27	216	466	2.16
Missouri	186	416	2.24	207	491	2.37
Montana	201	883	4.39	244	961	3.93
New Mexico	262	908	3.47	292	839	2.87
North Dakota	219	895	4.09	244	889	3.64
Ohio	142	560	3.94	197	839	4.26
Oklahoma	167	437	2.62	178	463	2.60
Pennsylvania:						
Anthracite	230	504	2.19	253	548	2.17
Bituminous	226	905	4.00	259	1,012	3.91
Tennessee	220	640	2.91	239	666	2.79
Texas	233	411	1.76	218	444	2.04
Utah	208	872	4.19	228	1,140	5.00
Virginia	235	907	3.86	272	993	3.65
Washington	169	501	2.96	217	633	2.92
West Virginia	208	1,017	4.89	237	1,108	4.68
Wyoming	201	905	4.50	248	1,090	4.40

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In most of the bituminous coal mines of the United States the length of the working day is 8 hours. In 1916, out of a total of 5,278 mines for which the number of hours worked per day were reported, 3,081, or 58 per cent worked 8 hours; 1,024, or 20 per cent, worked 9 hours; and 1,173, or 22 per cent, worked 10 hours. The corresponding percentages in 1915 for 5,076 mines were 60, 22, and 18. The 8-hour mines employed in 1916 a total of 316,133 men; the 9-hour mines, 93,619 men; and the 10-hour mines, 129,283 men. In comparing the figures for 1915 and 1916 it will be noted that the number of both mines and men working 9 hours showed increase, the largest increase of men having been in West Virginia and of mines in Pennsylvania.

It should be remembered, however, that when the length of the working day is stated, reference is made to the number of hours the mines are supposed to have been in operation and not to the number of hours worked by the miners. In both the anthracite and the bituminous fields practically all the coal is mined by contract at an agreed rate per ton or other basis of payment. The miner is an independent contractor and is not obliged to put in a certain number of hours at his working place. The figures in the following table really indicate the number of hours the men were given the opportunity to work and do not mean that all the employees worked, 8, 9, or 10 hours, as the case may have been.

Length of working day in coal mines in the United States in 1915 and 1916.

State.	8 hours.		9 hours.		10 hours.		All others.
	Mines.	Men.	Mines.	Men.	Mines.	Men.	Men.
1915.							
Alabama	13	369	44	4,402	133	17,109	711
Arkansas	58	3,589	.....	.....	.....	.....	162
Colorado	153	12,259	1	2	.....	.....	111
Illinois	416	74,619	6	32	.....	.....	959
Indiana	193	22,364	4	12	7	69	332
Iowa	167	15,308	3	24	.....	.....	217
Kansas	124	12,870	.....	.....	.....	.....	390
Kentucky	58	5,249	75	7,325	188	14,793	593
Maryland	5	142	2	8	48	5,254	260
Michigan	17	2,569	.....	.....	.....	.....	.....
Missouri	161	8,906	2	53	2	38	176
Montana	36	3,108	.....	.....	.....	.....	50
New Mexico	35	4,042	2	146	1	8	9
North Dakota	19	76	7	27	17	471	16
Ohio	500	38,410	19	287	3	20	1,336
Oklahoma	88	7,833	.....	.....	2	49	575
Oregon	3	92	.....	.....	.....	.....	59
Pennsylvania (bituminous)	779	90,999	278	40,159	275	40,646	2,789
Tennessee	4	229	61	5,412	28	2,694	613
Texas	19	2,935	8	301	16	1,458	393
Utah	21	3,556	.....	.....	.....	.....	8
Virginia	.....	.....	8	200	56	8,759	.....
Washington	52	4,809	.....	.....	.....	.....	41
West Virginia	39	3,741	389	34,446	371	35,896	1,799
Wyoming	48	7,234	1	2	1	4	4
	3,018	325,308	910	92,838	1,148	127,268	11,603

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Length of working day in coal mines in the United States in 1915 and 1916—Continued.

State.	8 hours.		9 hours.		10 hours.		All others.
	Mines.	Men.	Mines.	Men.	Mines.	Men.	Men.
1916.							
Alabama	9	306	40	2,724	132	20,376	1,902
Arkansas	60	3,628					144
Colorado	159	12,542			1	2	560
Illinois	437	74,702	8	56	1	3	777
Indiana	184	22,982	2	39	6	106	888
Iowa	160	13,574	3	22	1	16	831
Kansas	131	11,522					610
Kentucky	62	5,486	87	6,736	183	16,355	2,655
Maryland	1	3	10	205	58	5,390	35
Michigan	16	2,535					
Missouri	158	9,340	1	6	4	92	216
Montana	41	3,776					5
New Mexico	24	2,890	2	48	1	2	1,582
North Dakota	17	87	5	41	17	554	32
Ohio	521	40,052	20	327	4	30	985
Oklahoma	95	7,521			3	81	198
Oregon	4	59					47
Pennsylvania (bituminous)	828	84,794	338	38,436	299	37,468	7,514
Tennessee	2	51	60	5,110	24	3,196	354
Texas	22	2,566	13	762	12	1,153	
Utah	20	3,051	1	3			75
Virginia	3	47	8	107	56	9,536	87
Washington	44	4,793					4
West Virginia	35	2,994	426	38,997	371	34,923	1,153
Wyoming	48	6,882					373
	3,081	316,133	1,024	93,619	1,173	129,283	21,527

STRIKES AND SUSPENSIONS.

The record of strikes and suspensions in 1916 is remarkable in that the total time lost was for an "even" year relatively so small. On April 1 of the "even" years the biannual wage agreements in the larger bituminous coal-producing States expire, and there is usually a protracted period, beginning in April, of labor suspension pending the settlement of new wage scales. In 1916, however, there were no general strikes called in connection with the wage adjustments. Notwithstanding that in some fields, particularly in western Pennsylvania and in the Southwestern States of Kansas, Oklahoma, Arkansas, Missouri, and Texas there were protracted suspensions, the total number of days reported lost at the bituminous mines of the country in 1916 because of strikes was little greater than in 1915 and was only one-fifth as great in 1914. The practical absence of lost time because of labor disputes in Colorado in 1916 is notable in view of the recent history of labor troubles in that State.

The time lost because of labor troubles in the spring and summer of 1916 did not in general represent an economic loss of production, as the possibility of such suspension of mining operations had been discounted in advance and industries dependent on coal had accumulated stocks on which to draw. Furthermore, in the Middle West the usual slackening of demand in the summer relieved the urgency for output. The protracted suspension of operations in the Pittsburgh district in June and in the Southwestern States in September and October were exceptions in that they occurred at a time of urgent call for coal from these fields.

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Labor strikes in the coal mines of the United States in 1915 and 1916.

State.	1915			1916		
	Number of men on strike.	Total days lost.	Average number of days lost per man.	Number of men on strike.	Total days lost.	Average number of days lost per man.
Alabama	175	1,290	7	300	920	3
Arkansas	225	20,304	22	1,009	30,847	31
Colorado	90	13,500	150	38	82	2
Illinois	5,251	276,458	53	5,043	55,416	11
Indiana	1,472	21,361	15	8,154	154,974	19
Iowa	1,067	5,229	5	2,244	32,587	15
Kansas	1,716	17,425	10	6,306	152,838	24
Kentucky	1,045	16,455	16	4,330	239,859	56
Maryland				181	6,546	36
Michigan				1,416	18,189	13
Missouri	939	4,597	5	2,331	14,837	6
Montana	183	1,064	6	396	1,530	4
North Dakota				26	78	3
Ohio	15,048	1,722,013	114	7,594	156,689	21
Oklahoma	1,013	4,485	4	6,240	126,452	20
Pennsylvania (bituminous)	5,583	78,446	14	36,276	1,200,479	33
Tennessee				350	3,784	11
Texas	230	760	3	2,218	62,905	28
Utah				181	543	3
Virginia	7	7	1			
Washington				1,208	13,304	11
West Virginia	1,902	66,698	35	4,540	86,352	19
Wyoming	219	2,628	12	276	308	1
Total bituminous	36,865	2,252,740	61	91,152	2,389,519	26
Pennsylvania anthracite	30,325	214,691	7	79,481	955,067	12

Summary of labor strikes in the coal mines of the United States, 1899–1916.

Year.	Number of men on strike.	Total working days lost.	Average number of days lost per man.
1899	45,961	2,124,154	46
1900	131,973	4,878,102	37
1901 [a]	20,598	733,802	35
1902	200,452	16,672,217	83
1903 [a]	47,481	1,341,031	28
1904	77,661	3,382,330	44
1905	37,542	796,735	21
1906	372,343	19,201,348	51.5
1907 [a]	32,540	462,392	14
1908 [a]	145,145	5,449,938	38
1909 [a]	24,763	728,634	29
1910	218,493	19,250,524	88
1911	41,413	983,737	24
1912	311,056	12,527,305	40
1913	135,395	3,049,412	22.5
1914	161,720	11,013,667	68
1915	67,190	2,467,431	37
1916	170,633	3,344,586	20

[a] Bituminous mines only.

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MINING METHODS.

The term "mining method" as used here refers to the manner in which the coal is broken down in the mine and not to the system of mining, as by room and pillar or long wall. In the mine the coal is either blasted from a solid face—shot from the solid—as in hard-rock mining, or is shot loose or otherwise broken down after a preliminary cut into the coal has been made. This cut may be made by hand or by machine. Underground methods are therefore classified as shot from the solid, mined by hand, and mined by machines. An increasing quantity of coal is being recovered each year by stripping the cover from the bed in open pits by steam shovels. The bed thus exposed is for the most part shattered by powder and shoveled into cars by hand, although in places it is picked up directly by small steam shovels.

Opposition to shooting from the solid has developed, because it is injurious to the mining property in that the unusual charges of powder weaken the roof and pillars, which increases the liability to falls of roof and coal, the most prolific cause of fatal accidents to coal miners. Another objection to this method is that the heavy charges of powder required to blow down the coal where it has not been previously undercut or sheared cause the production of a very high proportion of fine coal and render the lump coal so friable that it disintegrates in handling and in transportation. With the growing use of mechanical stokers and of powdered coal the latter objection is losing much of its force, but the danger attending the method has been in no wise diminished, and it is forbidden by law in some of the coal-mining States. There was a slight increase in the total output shot from the solid in 1916 compared with 1915.

The use of mining machines was an important factor in enabling the coal industry in 1916 to increase the output 13.5 per cent with only a slightly augmented supply of labor. The per cent of machine-mined bituminous coal to the total production increased from 55 in 1915 to 56.5 in 1916, and the average number of tons recovered by each machine increased from 15,501 in 1915 to 17,515 in 1916.

The bituminous coal recovered from steam-shovel pits, although representing only the increase from 0.6 to 0.8 per cent of the total, was greater by about 1,100,000 tons, or 40 per cent, in 1916 than in 1915.

Mining conditions in the Pennsylvania anthracite region, where the beds are steeply inclined, faulted, and folded, are quite different from those in the greater part of the bituminous regions, where the beds are usually quite regular and approximately horizontal, and the methods pursued in recovering the coal are correspondingly different in the two areas. For the most part, anthracite is shot from the solid, and the practice in that region does not appear to have met with the objections that have developed in the bituminous fields. As is shown in the table on page 921, machine mining in the anthracite region has not been developed to any great extent, and less than 3 per cent of the total product was recovered in that manner in 1916; in fact, the quantity taken from steam-shovel pits was greater than that mined by machines.

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Bituminous coal mined by different methods in 1915.

State.	Mined by hand.		Shot from the solid.		Mined by machines.		From steam-shovel pits.		Not reported.		Total production (net tons).
	Quantity (net tons).	Percentage.	Quantity (net tons).	Percentage.	Quantity (net tons).	Percentage.	Quantity (net tons).	Percentage.	Quantity (net tons).	Percentage.	
Alabama	4,634,815	31.0	5,001,653	33.5	5,285,133	35.4	(a)	.....	a 6,336	0.1	14,927,937
Arkansas	5,975	.4	1,245,362	75.4	391,873	23.7	.....	.....	8,896	.5	1,652,106
Colorado	4,985,983	57.8	975,346	11.3	2,628,300	30.5	.....	.....	35,351	.4	8,624,980
Georgia	5,655	4.2	128,841	95.8	.....	.....	.....	.....	.....	.....	134,496
Illinois	6,492,893	11.0	15,611,581	26.5	36,011,461	61.2	455,195	0.8	258,446	.5	58,829,576
Indiana	2,189,665	12.9	4,119,406	24.2	9,930,445	58.4	638,220	3.7	128,416	.8	17,006,152
Iowa	1,445,953	19.0	5,668,319	74.4	414,606	5.5	.....	.....	85,265	1.1	7,614,143
Kansas	483,577	7.1	5,492,323	80.5	43,394	.6	780,787	11.4	24,393	.4	6,824,474
Kentucky	1,444,564	6.8	2,273,442	10.6	17,468,502	81.8	.....	.....	175,166	.8	21,361,674
Maryland	3,777,678	90.4	156,957	3.7	234,651	5.4	.....	.....	21,191	.5	4,180,477
Michigan	34,293	3.0	148,694	12.8	973,151	84.2	.....	.....	.....	.....	1,156,138
Missouri	807,677	21.2	1,328,458	34.9	861,957	22.6	655,670	17.2	157,831	4.1	3,811,593
Montana	641,591	23.0	586,611	21.0	1,534,064	55.0	.....	.....	27,489	1.0	2,789,755
New Mexico	3,043,578	79.7	117,456	3.1	644,698	16.9	.....	.....	12,208	.3	3,817,940
North Dakota	24,129	4.6	211,917	40.1	203,775	38.6	.....	.....	88,257	16.7	528,078
Ohio	934,651	4.2	622,236	2.8	20,008,259	89.2	273,263	1.2	596,282	2.6	22,434,691
Oklahoma	118,918	3.2	2,409,284	65.2	1,122,512	30.4	28,484	.8	14,382	.4	3,693,580
Pennsylvania (bituminous)	54,502,149	34.5	15,310,937	9.7	87,752,569	55.6	.....	.....	389,482	.2	157,955,137
Tennessee	2,242,321	39.1	1,974,772	34.5	1,507,425	26.3	.....	.....	5,843	.1	5,730,361
Texas	1,596,305	76.4	458,500	22.0	34,103	1.6	.....	.....	.....	.....	2,088,908
Utah	1,471,596	47.3	91,479	2.9	1,540,737	49.6	.....	.....	4,908	.2	3,108,715
Virginia	235,449	2.9	2,753,987	33.91	5,130,827	63.17	.....	.....	2,333	.02	8,122,596
Washington	1,038,017	42.7	1,060,480	44.5	310,598	12.8	.....	.....	.....	.....	2,429,095
West Virginia	30,307,708	39.3	474,694	.6	46,288,657	60.0	.....	.....	118,010	.1	77,184,069
Wyoming	1,436,816	21.9	2,189,097	33.4	2,923,582	44.6c	.....	.....	4,533	.1	6,554,028
Other States	22,249	34.9	26,718	41.9	2,272	3.6	.....	.....	12,488	19.6	63,727
Total bituminous	123,924,205	28.0	70,458,550	15.9	243,237,551	55.0	2,831,619	.6	2,172,501	.5	442,624,426
Pennsylvania (anthracite)	(b)	.....	(b)	.....	(b)	.....	c 1,121,603	1.3	87,873,458	98.7	88,995,061

a A small quantity of coal taken from one steam-shovel pit included with that not reported by methods.
b This information not requested by the United States Geological Survey.
c Includes a small quantity of anthracite recovered from culm banks.

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Bituminous coal mined by different methods in 1916.

State.	Mined by hand.		Shot from the solid.		Mined by machines.		From steam-shovel pits.		Not reported.		Total production (net tons).
	Quantity (net tons).	Percentage.	Quantity (net tons).	Percentage.	Quantity (net tons).	Percentage.	Quantity (net tons).	Percentage.	Quantity (net tons).	Percentage.	
Alabama	5,658,300	31.3	6,547,225	36.2	5,802,150	32.1	75,462	0.4	3,060	.....	18,086,197
Arkansas	133,056	6.7	1,627,894	81.6	224,245	11.2	.....	.....	9,720	0.5	1,994,915
Colorado	5,393,195	51.4	1,686,824	16.1	3,342,345	31.9	.....	.....	61,873	.6	10,484,237
Georgia	6,000	3.5	167,554	96.5	.....	.....	.....	.....	.....	.....	173,554
Illinois	7,290,436	11.0	17,369,083	26.2	40,791,408	61.7	467,863	.7	276,546	.4	66,195,336
Indiana	1,822,130	9.1	5,904,187	29.4	11,367,758	56.6	849,838	4.2	149,615	.7	20,093,528
Iowa	1,237,257	17.0	5,302,218	73.0	636,892	8.8	.....	.....	84,433	1.2	7,260,800
Kansas	592,692	8.5	5,367,550	78.0	37,897	.6	858,370	12.5	24,946	.4	6,881,455
Kentucky	1,521,424	6.0	2,274,763	9.0	21,441,700	84.4	.....	.....	156,110	.6	25,393,997
Maryland	3,982,741	89.3	227,965	5.1	221,609	5.0	.....	.....	27,731	.6	4,460,046
Michigan	26,110	2.2	107,062	9.1	1,044,583	88.5	.....	.....	2,605	.2	1,180,360
Missouri	920,786	19.4	1,637,464	34.6	947,811	20.0	1,026,291	21.6	209,794	4.4	4,742,146
Montana	1,238,600	34.1	344,438	9.5	2,024,799	55.7	.....	.....	24,690	.7	3,632,527
New Mexico	3,102,162	81.7	168,804	4.5	510,219	13.5	.....	.....	11,826	.3	3,793,011
North Dakota	40,307	6.3	278,147	43.8	218,276	34.4	.....	.....	98,182	15.5	634,912
Ohio	1,271,373	3.7	731,801	2.1	31,669,049	91.1	551,190	1.6	504,806	1.5	34,728,219
Oklahoma	51,039	1.4	2,185,592	60.6	1,258,022	34.8	103,381	2.9	9,977	.3	3,608,011
Pennsylvania (bituminous)	59,598,251	35.0	15,848,717	9.3	94,391,391	55.4	.....	.....	457,065	.3	170,295,424
Tennessee	2,079,976	33.9	2,524,603	41.1	1,517,426	24.7	.....	.....	15,444	.3	6,137,449
Texas	1,550,257	78.0	418,246	21.0	19,000	1.0	.....	.....	.....	.....	1,987,503
Utah	1,486,714	41.7	30,309	.8	2,050,405	57.5	.....	.....	.....	.....	3,567,428
Virginia	426,605	4.4	3,266,701	33.7	6,011,262	61.9	.....	.....	2,906	.....	9,707,474
Washington	1,768,549	58.2	992,803	32.7	277,236	9.1	.....	.....	.....	.....	3,038,588
West Virginia	31,480,529	36.5	450,501	.5	54,408,511	62.9	(a)	.....	120,586	.1	86,460,127
Wyoming	1,802,804	22.8	2,626,099	33.1	3,477,081	44.0	.....	.....	4,663	.1	7,910,647
Other States	34,484	48.0	25,693	35.8	400	.6	.....	.....	11,214	15.6	71,791
Total bituminous	134,515,777	26.8	78,112,243	15.5	283,691,475	56.4	3,932,395	.8	2,267,792	.5	502,519,682
Pennsylvania anthracite	(b)	.....	(b)	.....	1,839,506	2.1	c 1,987,800	2.3	.....	.....	87,578,493

a A small quantity of coal taken from one steam-shovel pit included with that not reported by methods.
b This information not requested by the United States Geological Survey.
c Includes a small quantity of anthracite recovered from culm banks.

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Bituminous coal mined by machines in the United States, 1915 and 1916.

State.	Machines in use.		Quantity mined by machines (net tons).		Percentage of total product mined by machines.	
	1915	1916	1915	1916	1915	1916
Alabama	373	320	5,285,133	5,802,150	35.4	32.1
Arkansas	24	20	391,873	224,245	23.7	11.2
Colorado	299	305	2,628,300	3,342,345	30.5	31.9
Illinois	1,787	1,938	36,011,461	40,791,408	61.2	61.7
Indiana	660	661	9,930,445	11,367,758	58.4	56.6
Iowa	45	56	414,606	636,892	5.5	8.8
Kansas	9	6	43,394	37,897	.6	.6
Kentucky	1,399	1,528	17,468,502	21,441,700	81.8	84.4
Maryland	12	16	224,651	221,609	5.4	5.0
Michigan	107	104	973,151	1,044,583	84.2	88.5
Missouri	97	93	861,957	947,811	22.6	20.0
Montana	100	103	1,534,064	2,024,799	55.0	55.7
New Mexico	42	51	644,698	510,219	16.9	13.5
North Dakota	14	13	203,775	218,276	38.6	34.4
Ohio	1,459	1,604	20,008,259	31,669,049	89.2	91.1
Oklahoma	140	167	1,122,512	1,258,022	30.4	34.8
Pennsylvania	5,935	5,768	87,752,569	94,391,391	55.6	55.4
Tennessee	193	213	1,507,425	1,517,426	26.3	24.7
Texas	10	10	34,103	19,000	1.6	1.0
Utah	67	78	1,540,737	2,050,405	49.6	57.5
Virginia	186	194	5,130,827	6,011,262	63.2	61.9
Washington	73	55	310,598	277,236	12.8	9.1
West Virginia	2,479	2,702	46,288,657	54,408,511	60.0	62.9
Wyoming	179	192	2,923,582	3,477,081	44.6	44.0
Other States	3	(a)	2,272	400	4.6	.6
	15,692	16,197	243,237,551	283,691,475	b 55.0	56.5

a Can not be disclosed. b Average.

Bituminous coal mined by machines in the United States, 1891–1916.

Year.	Machines in use.	Quantity mined by machines (net tons).	Average production for each machine (net tons).	Year.	Machines in use.	Quantity mined by machines (net tons).	Average production for each machine (net tons).
1891	545	6,211,732	11,398	1906	10,212	118,847,527	11,638
1896	1,446	16,424,932	11,373	1907	11,144	138,547,823	12,432
1897	1,956	22,649,220	11,579	1908	11,569	123,183,334	10,648
1898	2,622	32,413,144	12,362	1909	13,049	142,496,578	10,920
1899	3,125	43,963,933	14,068	1910	13,254	174,012,393	13,127
1900	3,907	52,784,523	13,510	1911	13,829	178,158,236	12,854
1901	4,341	57,843,335	13,325	1912	15,298	210,538,822	13,763
1902	5,418	69,611,582	12,848	1913	16,379	242,421,713	14,801
1903	6,658	77,974,894	11,712	1914	16,507	218,399,287	13,231
1904	7,663	78,606,997	10,258	1915	15,692	243,237,551	15,501
1905	9,184	103,396,452	11,258	1916	16,197	283,691,475	17,515

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Anthracite coal mined by machines, 1911–1916.

Year.	Quantity (gross tons).	Year.	Quantity (gross tons).
1911	62,417	1914	818,389
1912	219,836	1915	1,167,639
1913	406,220	1916	1,642,416

Coal recovered from steam-shovel strip pits in 1915 and 1916.

State.	Number of shovels.	Quantity of coal mined (net tons).	Average tonnage per man.	
			Per day.	Per year.
1915.				
Alabama	1	(a)		
Illinois	10	455,195	8.7	1,979
Indiana	22	638,220	8.3	1,474
Kansas	23	780,787	5.3	1,169
Missouri	20	655,670	4.4	870
Ohio	7	273,263	7.0	1,763
Oklahoma	4	28,484	4.3	274
Total bituminous (except Alabama)	87	2,831,619	6.0	1,208
Pennsylvania anthracite	57	1,121,603		
Grand total (except Alabama)	144	3,953,222		
1916.				
Alabama	4	75,462	4.1	1,078
Illinois	10	467,363	8.7	1,982
Indiana	22	849,338	7.7	1,364
Kansas	24	858,370	5.8	1,148
Missouri	27	1,026,291	5.3	1,116
Ohio	18	551,190	10.6	2,250
Oklahoma	5	103,381	6.1	708
West Virginia	1	(b)		
Total bituminous (except West Virginia)	111	3,932,395	6.6	1,316
Pennsylvania anthracite	105	1,987,800		
Grand total (except West Virginia)	216	5,920,195		

a Only one steam shovel was in use in Alabama, and the extent of its operations can not be revealed.
b Only one shovel was used in West Virginia and the extent of its operations can not be revealed.

COAL-WASHING OPERATIONS.

Not all coal can be cleaned by hand picking. Some coal beds or parts of beds have layers or benches of slate and bone or contain more than the allowable quantity of sulphur in the form of iron pyrite so thoroughly mixed with the coal that crushing is necessary to free the coal from the refuse. To clear such coal washing is resorted to and the coal, being lighter than the refuse, is separated by currents of water. Coal is also cleaned in the dry state, and the product of one large company in Illinois is so treated, the results being included in the statistics of washed coal. A large part of the washed coal is slack used in the manufacture of coke, notably in Pennsylvania and West Virginia. In the statement of the total production of coal in the United States the refuse is deducted and only the cleaned coal is considered as the marketed or commercial product.

Alabama leads in quantity of coal washed, almost 42 per cent of the total quantity so treated in 1916 being from that State.

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Bituminous coal washed at the mines in 1915 and 1916.

State.	Coal washed (net tons).	Cleaned coal (net tons).	Refuse (net tons).	Percentage of cleaned coal to total State output.
1915.				
Alabama	8,734,475	7,920,122	814,353	53.0
Colorado	353,792	293,201	60,591	3.5
Georgia	99,895	78,996	20,899	58.0
Illinois	3,323,321	2,891,001	432,320	5.0
Indiana	102,527	87,832	14,695	.5
Kansas, Michigan, Missouri, New Mexico, Oklahoma, and Texas	944,967	768,940	176,027	3.6
Kentucky	283,613	249,923	33,690	1.2
Montana and Oregon	647,783	603,496	44,287	22.0
Ohio	221,341	195,091	26,250	.9
Pennsylvania	4,740,673	4,317,338	423,335	2.5
Tennessee	560,022	495,907	64,115	9.0
Virginia	194,179	178,525	15,654	2.0
Washington	1,304,617	981,817	322,800	4.0
West Virginia	1,960,831	1,811,538	149,293	2.3
	23,472,036	20,873,727	2,598,309	5.0
1916.				
Alabama	10,695,700	9,742,467	953,233	53.9
Colorado	323,064	273,645	49,419	2.6
Georgia	114,571	87,178	27,393	50.2
Illinois	3,480,849	3,017,876	462,973	4.6
Indiana	97,326	84,008	13,318	.4
Kansas, Michigan, and Texas	217,224	187,454	29,770	1.9
Kentucky	400,243	350,853	49,390	1.4
Missouri	144,252	109,689	34,563	2.3
Montana	464,057	401,157	62,900	11.0
New Mexico	1,009,338	844,083	165,255	22.3
Ohio	172,015	151,761	20,254	.4
Oklahoma	10,083	6,875	3,208	.2
Oregon	17,373	15,333	2,040	36.0
Pennsylvania	4,335,661	3,941,355	394,306	2.3
Tennessee	597,481	546,034	51,447	8.9
Virginia	62,445	57,120	5,325	.6
Washington	1,275,925	1,099,453	176,472	38.2
West Virginia	2,215,367	2,005,877	209,490	2.3
	25,632,974	22,922,218	2,710,756	4.8

COAL CONSUMED BY RAILROADS.

In 1916 the railroads in the United States consumed 142,735,000 net tons of bituminous coal and anthracite, or 24 per cent of the output, compared with 128,200,000 net tons used in 1915, which was also 24 per cent of the total output in that year. The quantity of bituminous coal so used in 1916 was 136,000,000 tons, or 27 per cent of the bituminous output, against 122,000,000 tons, or 28 per cent, in 1915. The increase in the quantity of bituminous coal used by railroads in 1916 over 1915 was 14,000,000 tons, or 11.5 per cent. The quantity of Pennsylvania anthracite used by railroads in 1916 was 6,735,000 net tons, or 8 per cent of the output, an increase over the quantity so used in 1915 of 535,000 net tons, or 9 per cent. Of the total coal used by railroads, 62,700,000 tons of bituminous and nearly all the anthracite (6,702,000 net tons), or 49 per cent, was used by roads in the northeastern part of the country; 23,300,000 tons of bituminous coal, or 16 per cent, was used in the Southern States; and 50,000,000 tons of bituminous coal, or 35 per cent, was used in the West.

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The roads in the Eastern States used 6,200,000 tons, or 11 per cent, more bituminous coal in 1916 than in 1915; the roads in the South, 1,300,000 tons, or 6 per cent, more than in 1915; and the roads in the West, 6,500,000 tons, or 15 per cent, more than in 1915. The roads in the Northwest used nearly 400,000 tons more of Lake-cargo coal than in 1915. The information available indicates that the coastwise movement of coal for railroad consumption, nearly all of which goes to New England, fell off between 700,000 and 800,000 net tons, or about 38 per cent.

These statistics were compiled from reports made to the Geological Survey by all the larger roads and a number of the smaller roads, supplemented by estimates of coal used by the other small roads, which estimates represent less than 4 per cent of the total.

The information requested of the railroad companies included the quantity of coal used and the States where the coal was mined. It is obviously impracticable to attempt to show the States where the railroad fuel was consumed. The following tables show comparative totals for 1915 and 1916, the quantity of railroad fuel received from each State, the district in which it was used, and the total consumed in each district. The districts are those defined by the Interstate Commerce Commission, as follows: [1]

For the purposes of this report, the railway companies listed have severally been assigned to three so-called districts, which are defined below. These districts correspond in a general way to the territories covered by the three general freight classifications in use throughout the United States, namely, the official, the southern, and the western.

The eastern district comprises that portion of the United States bounded on the west by the northern and western shore of Lake Michigan to Chicago, thence to Peoria, thence to East St. Louis, thence down the Mississippi River to the mouth of the Ohio River; and on the south by the Ohio River from its mouth to Parkersburg, W. Va.; thence to the southwestern corner of Maryland; thence by the Potomac River to its mouth.

The southern district comprises that portion of the United States bounded on the north by the eastern district and on the west by the Mississippi River.

The western district comprises the remainder of the United States, except Alaska and island possessions.

The assignment of carriers to the several districts is necessarily arbitrary in those cases in which carriers operate in more than one of them.

The coal used for railroad fuel from all States except Ohio, Pennsylvania, Virginia, and West Virginia is either taken by the roads that enter the fields or is delivered to the consuming road by all-rail routes, except possibly that some coal from Pennsylvania and West Virginia which is shipped west and south on Kanawha and Ohio rivers may be used by railroads. The fuel supply for railroads in New England is shipped either by all-rail routes across New York from Pennsylvania and, to a less extent, from Maryland and West Virginia, or by coastwise vessels to New England ports from the terminal piers of railroads that reach the coal fields to the south. Coal from both Virginia and West Virginia was shipped coastwise in this manner from Hampton Roads in 1915 and 1916 and used by railroads in New England. Likewise railroads reaching the docks at the head of the Great Lakes use coal from all four of the States that ship by vessel from lower Lake ports.

[1] A preliminary abstract of statistics of common carriers for the year ended June 30, 1914, p. 5, Interstate Commerce Commission, 1915.

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Coal consumed by railroads in the United States, 1915 and 1916, in net tons.

State in which coal was produced.	Eastern district.	Southern district.	Western district.	Total.
1915.				
Alabama	.....	4,897,710	174,725	5,072,435
Arkansas	.....	.....	803,295	803,295
Colorado	.....	.....	2,388,515	2,388,515
Georgia	.....	5,000	.....	5,000
Illinois	5,710,807	1,937,547	11,279,668	18,928,022
Indiana	4,375,204	1,254,713	558,633	6,188,550
Iowa	.....	.....	4,415,832	4,415,832
Kansas	.....	.....	3,154,501	3,154,501
Kentucky	389,546	3,764,355	495,922	4,649,823
Maryland	387,121	.....	.....	387,121
Michigan	394,921	.....	.....	394,921
Missouri	600,000	.....	1,751,940	2,351,940
Montana	.....	.....	1,050,319	1,050,319
New Mexico	.....	.....	1,635,752	1,635,752
North Dakota	.....	.....	3,109	3,109
Ohio:				
Shipped all rail	7,837,124	.....	58,609	
Shipped via Lakes	.....	.....	310,395	
Total	.....	.....	369,004	8,206,128
Oklahoma	.....	.....	2,573,750	2,573,750
Oregon	.....	.....	5,000	5,000
Pennsylvania:				
Shipped all rail	29,786,032	126,569	827,005	
Shipped via Lakes	.....	.....	3,435,693	
Total	.....	.....	4,262,698	34,175,299
Tennessee	.....	3,375,461	.....	3,375,461
Texas	.....	.....	1,037,249	1,037,249
Utah	.....	.....	565,489	565,489
Virginia:				
Shipped all rail	300,000	2,226,716	.....	
Shipped via tidewater	300,000	.....	.....	
Total	600,000	.....	.....	2,826,716
Washington	.....	.....	1,149,446	1,149,446
West Virginia:				
Shipped all rail	4,492,029	4,411,929	574,443	
Shipped via Lakes	.....	.....	800,134	
Shipped via tidewater	1,776,419	.....	.....	
Total	6,268,448	.....	1,374,577	12,054,954
Wyoming	.....	.....	4,223,290	4,223,290
Imports	150,797	.....	227,286	378,083
Total bituminous coal	56,500,000	22,000,000	43,500,000	122,000,000
Pennsylvania anthracite	6,200,000	.....	.....	6,200,000
Grand total	62,700,000	22,000,000	43,500,000	128,200,000
1916.				
Alabama	.....	4,092,666	533,574	4,626,240
Arkansas	.....	.....	593,956	593,956
Colorado	.....	.....	2,415,779	2,415,779
Georgia	.....	2,242	154	2,396
Illinois	4,519,505	3,099,832	15,199,496	22,818,833
Indiana	5,776,236	392,953	360,006	6,529,195
Iowa	20,162	.....	4,293,973	4,314,135
Kansas	.....	.....	3,237,580	3,237,580
Kentucky	301,935	3,637,944	247,662	4,187,541
Maryland:				
Shipped all rail	250,905	208	.....	
Shipped via tidewater	797	.....	.....	
Total	251,702	.....	.....	251,910
Michigan	341,693	.....	.....	341,693
Missouri	132,376	.....	1,543,774	1,676,150
Montana	.....	.....	1,967,574	1,967,574
New Mexico	.....	.....	1,567,269	1,567,269
North Dakota	.....	.....	3,329	3,329

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Coal consumed by railroads in the United States, 1915 and 1916, in net tons—Continued.

State in which coal was produced.	Eastern district.	Southern district.	Western district.	Total.
1916—Continued.				
Ohio:				
Shipped all rail	10,410,265	28,495	10,427	
Shipped via lakes			633,000	
Total			643,427	11,082,187
Oklahoma			2,254,160	2,254,160
Oregon			4,789	4,789
Pennsylvania:				
Shipped all rail	29,484,511		562,269	
Shipped via tidewater	100,548			
Shipped via lakes			3,546,611	
Total	29,585,059		4,108,880	33,693,939
Tennessee	336	2,816,543	2,560	2,819,439
Texas			994,530	994,530
Utah			693,138	693,138
Virginia:				
Shipped all rail	4,596	2,142,200	603	
Shipped via tidewater	599,937			
Total	604,533			2,747,336
Washington			1,601,274	1,601,274
West Virginia:				
Shipped all rail	8,794,573	6,991,108		
Shipped via lakes			743,655	
Shipped via tidewater	490,763	95,809		
Total	9,285,336	7,086,917		17,115,908
Wyoming			4,963,440	4,963,440
Imports:				
Canada	47,844		376,863	
Australia			95	
Total			376,958	424,802
Source not known	1,423,018		1,648,460	3,071,478
Total bituminous coal	62,700,000	23,300,000	50,000,000	136,000,000
Pennsylvania anthracite:				
Shipped all rail	6,700,554	1,340	28,341	
Shipped via tidewater	1,641			
Shipped via lakes			3,150	
Total	6,702,195	1,340	31,491	6,735,026
Grand total	69,402,195	23,301,340	50,031,491	142,735,026

Coke consumed by railroads in the United States, 1916, in net tons.

State in which coke was produced.	Eastern district.	Southern district.	Western district.	Total.
Illinois	104		2,684	2,788
Indiana	731			731
Michigan	1,073			1,073
Ohio	585			585
West Virginia		11,797	603	12,400
Iowa			136	136
Colorado			1,388	1,388
Minnesota			519	519
Missouri			59	59
Pennsylvania			1,721	1,721
Utah			552	552
Washington			292	292
Wisconsin			257	257
Shipped via lakes[a]			450	450
	2,493	11,797	8,661	22,951

[a] Source not known.

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Coal consumed by railroads in the United States, 1915 and 1916, in net tons.

District.	1915	1916
Eastern:		
Shipped all rail	54,272,784	61,460,111
Shipped via tidewater	2,076,419	1,192,045
Imported	150,797	47,844
Total bituminous	56,500,000	62,700,000
Pennsylvania anthracite	6,200,000	6,702,195
Total eastern district	62,700,000	69,402,195
Southern:		
Shipped all rail	22,000,000	23,204,191
Shipped via tidewater		95,809
Total bituminous	22,000,000	23,300,000
Pennsylvania anthracite		1,340
Total southern district	22,000,000	23,301,340
Western:		
Shipped all rail	38,726,492	44,699,776
Shipped via Lakes	4,546,222	4,923,266
Imported	227,286	376,958
Total bituminous	43,500,000	50,000,000
Pennsylvania anthracite		31,491
Total western district	43,500,000	50,031,491
Total bituminous coal	122,000,000	136,000,000
Total anthracite coal	6,200,000	6,735,026
Grand total	128,200,000	142,735,026

Bituminous coal shipped by railroads and waterways in the United States in 1916.

Route.	State.	Quantity.	Total.
Railroads.		*Net tons.*	*Net tons.*
Alaskan Engineering Commission	Alaska	6,233	6,233
Arkansas Central	Arkansas	20,270	20,270
Ashland Coal & Iron	Kentucky	99,179	99,179
Atchison, Topeka & Santa Fe	Colorado	624,422	4,944,953
	Illinois	400,310	
	Kansas	1,490,965	
	Missouri	488,797	
	New Mexico	1,847,129	
	Oklahoma	93,330	
Baltimore & Ohio and Baltimore & Ohio Southwestern.	Illinois and Indiana	1,472,574	33,578,376
	Maryland	78,162	
	Ohio	8,480,329	
	Pennsylvania	9,201,445	
	West Virginia	14,345,866	
Bessemer & Lake Erie	Pennsylvania	3,161,921	3,161,921
Buffalo, Rochester & Pittsburgh	do	8,655,661	8,655,661
Cambria & Indiana	do	977,112	977,112
Carolina, Clinchfield & Ohio	Kentucky and Virginia	1,873,205	1,873,205
Central of Georgia	Alabama and Georgia	787,216	787,216
Chesapeake & Ohio	Kentucky	2,567,896	25,562,184
	West Virginia	22,994,288	
Chicago & Alton	Illinois	2,375,187	2,623,002
	Missouri	247,815	
Chicago & Eastern Illinois	Illinois	5,188,097	10,464,037
	Indiana	5,275,940	
Chicago & Northwestern (includes Wyoming & Northwestern).	Illinois	3,960,745	5,626,466
	Iowa and Wyoming	1,665,721	
Chicago, Burlington & Quincy	Colorado	387,609	13,828,151
	Illinois	10,128,225	
	Iowa	752,374	
	Missouri	535,558	
	Wyoming	2,024,385	
Chicago, Indianapolis & Louisville	Indiana	1,143,177	1,143,177

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Bituminous coal shipped by railroads and waterways in the United States in 1916—Contd.

Route.	State.	Quantity.	Total.
Railroads—Continued.		*Net tons.*	*Net tons.*
Chicago, Milwaukee & St. Paul	Illinois	1,392,096	3,878,523
	Iowa	1,452,902	
	Montana, North Dakota, South Dakota, and Washington.	1,033,525	
Chicago, Peoria & St. Louis	Illinois	614,413	614,413
Chicago, Rock Island & Pacific (includes Chicago, Rock Island & Gulf and Keokuk & Des Moines.	Arkansas, Colorado, and Missouri.	232,412	3,263,073
	Illinois	160,322	
	Iowa	1,815,623	
	Oklahoma	1,036,814	
	Texas	17,902	
Chicago, Terre Haute & Southwestern	Indiana	3,950,693	3,950,693
Cincinnati, Hamilton & Dayton	Ohio	293,544	293,544
Cincinnati, Indianapolis & Western	Illinois	112,922	112,922
Cincinnati, New Orleans & Texas Pacific	Kentucky	72,227	362,955
	Tennessee	290,728	
Cleveland, Cincinnati, Chicago & St. Louis	Illinois	5,934,035	6,972,082
	Indiana	1,038,047	
Coal & Coke	West Virginia	968,717	968,717
Colorado & Southern	Colorado	2,253,105	2,253,105
Colorado Midland	....do	228,557	228,557
Cumberland	Kentucky	251,703	251,703
Cumberland & Pennsylvania	Maryland	2,706,058	2,706,058
Denver & Rio Grande (includes Ballard and Thompson, Kenilworth & Helper and Rio Grande Southern).	Colorado and New Mexico.	2,117,256	4,772,379
	Utah	2,655,123	
Denver & Salt Lake	Colorado	881,568	881,568
Detroit, Toledo & Ironton	Ohio	303,194	303,194
Elgin, Joliet & Eastern	Illinois	333,575	333,575
Erie	Ohio	116,055	1,609,865
	Pennsylvania	1,493,810	
Evansville & Indianapolis	Indiana	366,662	366,662
Evansville, Suburban & Newburgh	....do	95,287	95,287
Fort Dodge, Des Moines & Southern	Iowa	56,512	56,512
Fort Smith & Western	Oklahoma	57,119	57,119
Great Northern	Montana	959,617	1,028,190
	North Dakota	68,573	
Harriman & Northeastern	Tennessee	213,956	213,956
Hocking Valley	Ohio	3,719,696	3,719,696
Huntington & Broad Top Mountain	Pennsylvania	881,350	881,350
Illinois Central	Alabama	99,123	15,529,755
	Illinois	11,487,470	
	Indiana	371,291	
	Kentucky	3,571,871	
Illinois Traction System (includes Chicago, Ottawa & Peoria).	Illinois	490,576	490,576
Indian Creek Valley	Pennsylvania	59,623	59,623
International & Great Northern	Texas	317,197	317,197
Interstate	Virginia	1,217,006	1,217,006
Iowa & St. Louis	Iowa and Missouri	8,900	8,900
Kanawha & Michigan	Ohio	610,704	3,869,393
	West Virginia	3,258,689	
Kanawha & West Virginia	....do	211,769	211,769
Kansas City, Clinton & Springfield	Missouri	16,674	16,674
Kansas City Southern	Arkansas and Oklahoma	128,594	1,045,855
	Kansas	787,236	
	Missouri	130,025	
Lake Erie, Franklin & Clarion	Pennsylvania	444,085	444,085
Ligonier Valley	....do	923,225	923,225
Litchfield & Madison	Illinois	1,112,000	1,112,000
Louisville & Nashville (includes Warrior Mineral)	Alabama	3,462,984	16,810,958
	Illinois	850,952	
	Kentucky	11,020,486	
	Tennessee	1,312,828	
	Virginia	163,708	
Marietta, Columbus & Cleveland	Ohio	106,915	106,915
Michigan Central	Michigan	496,942	496,942
Midland Valley	Arkansas	364,415	364,415
Minneapolis & St. Louis	Illinois	800,187	1,165,884
	Iowa	365,697	
Minneapolis, St. Paul & Sault Ste. Marie	Montana and North Dakota.	213,426	213,426
Missouri, Kansas & Texas (includes Wichita Falls & Southern).	Kansas	635,924	2,270,922
	Missouri	52,878	
	Oklahoma	1,128,384	
	Texas	453,736	
Missouri, Oklahoma & Gulf	Oklahoma	417,537	417,537
Missouri Pacific	Kansas	1,438,349	2,647,387
	Missouri	1,209,038	
Mobile & Ohio	Alabama	264,082	1,151,470
	Illinois	887,388	
Monongahela	Pennsylvania	1,089,062	1,673,622
	West Virginia	584,560	

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Bituminous coal shipped by railroads and waterways in the United States in 1916—Contd.

Route.	State.	Quantity.	Total.
Railroads—Continued.		*Net tons.*	*Net tons.*
Montana, Wyoming & Southern	Montana	458,319	458,319
Montour	Pennsylvania	2,800,469	2,800,469
Morgantown & Kingwood	West Virginia	528,759	528,759
Nashville, Chattanooga & St. Louis	Alabama and Tennessee	1,074,874	1,074,874
New York Central (includes Lake Erie, Alliance & Wheeling, Lake Shore & Michigan Southern, and New York Central & Hudson River).	Ohio	2,081,608	10,939,768
	Pennsylvania	8,858,160	
Norfolk & Western	Kentucky	2,542,533	29,964,296
	Ohio	9,161	
	Virginia	2,839,981	
	West Virginia	24,572,621	
Northern Pacific (includes Yellowstone National Park Line).	Montana	937,103	2,941,634
	North Dakota	150,628	
	Washington	1,853,903	
Pennsylvania (includes Pittsburgh, Cincinnati, Chicago & St. Louis).	Ohio	9,583,897	68,082,018
	Pennsylvania	57,389,025	
	West Virginia	1,109,096	
Peoria & Pekin Union	Illinois	458,358	458,358
Peoria Railway Terminal	....do	322,284	322,284
Pere Marquette (includes Detroit, Bay City Western).	Michigan	600,165	600,165
Pittsburgh & Lake Erie	Pennsylvania	7,245,794	7,245,794
Pittsburgh & Shawmut	....do	2,280,695	2,280,695
Pittsburgh & Susquehanna	....do	350,458	350,458
Pittsburgh, Chartiers & Youghiogheny	....do	878,041	878,041
Pittsburgh, Lisbon & Western	Ohio and Pennsylvania	67,530	67,530
Pittsburgh, Shawmut & Northern	Pennsylvania	913,796	913,796
Quincy, Omaha & Kansas City	Missouri	112,398	112,398
St. Louis & Belleville Electric	Illinois	284,039	284,039
St. Louis, Iron Mountain & Southern (includes Dardanelle & Russellville).	Arkansas	886,085	4,247,335
	Illinois	3,361,250	
St. Louis-San Francisco	Alabama	2,125,149	5,760,943
	Arkansas	534,823	
	Kansas	2,193,227	
	Missouri	455,848	
	Oklahoma	451,896	
St. Louis Southwestern of Texas	Texas	75,789	75,789
Southern (includes Northern Alabama)	Alabama	3,491,855	9,522,720
	Illinois	1,110,313	
	Indiana	1,068,273	
	Kentucky	490,633	
	Tennessee	1,975,204	
	Virginia	1,386,442	
Southern Pacific (includes Galveston, Harrisburg & San Antonio and Houston & Texas Central).	California and Oregon	22,938	129,914
	Texas	106,976	
Tennessee Central	Tennessee	370,102	370,102
Toledo & Ohio Central	Ohio	1,375,673	1,375,673
Toledo, Peoria & Western	Illinois	167,787	167,787
Toledo, St. Louis & Western	Illinois and Indiana	596,909	596,909
Union	Pennsylvania	110,466	110,466
Union Pacific (includes Colorado, Wyoming & Eastern, Oregon Short Line, and Oregon-Washington R. R. & Navigation Co.).	Colorado	447,253	6,085,035
	Kansas and Missouri	95,947	
	Utah and Washington	195,562	
	Wyoming	5,346,273	
Vandalia	Illinois	861,514	6,138,006
	Indiana	5,276,492	
Virginia & Kentucky	Virginia	30,940	30,940
Virginian	Virginia and West Virginia.	5,519,643	5,519,643
Wabash	Illinois	2,542,237	2,927,799
	Iowa and Missouri	385,562	
Wabash, Chester & Western	Illinois	54,313	54,313
Wabash Pittsburgh Terminal	Ohio and West Virginia	349,929	1,095,389
	Pennsylvania	745,460	
Western Allegheny	....do	426,469	426,469
Western Maryland	Maryland	1,536,500	4,431,898
	Pennsylvania	195,749	
	West Virginia	2,699,649	
West Virginia Northern	....do	142,059	142,059
Wheeling & Lake Erie	Ohio	3,740,304	3,740,304
Zanesville & Western	....do	881,729	881,729
Miscellaneous:			
Alabama Central; Atlanta, Birmingham & Atlantic; Birmingham Southern; Mary Lee; Seaboard Air Line; Thomas & Sayreton; Woodstock & Beveton.	Alabama	4,213,623	4,213,623
Book Cliff; Colorado & Southeastern; Colorado & Wyoming; Denver & Intermountain; Trinidad Electric; Uintah.	Colorado	1,112,789	1,112,789

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Bituminous coal shipped by railroads and waterways in the United States in 1916—Contd.

Route.	State.	Quantity.	Total.
Railroads—Continued.			
Miscellaneous—Continued.		*Net tons.*	*Net tons.*
Chicago & Illinois Midland; Chicago, Indiana & Southern; Lake Erie & Western; Rock Island Southern.	Illinois	1,719,950	1,719,950
Illinois Southern; Marion & Eastern; St. Louis, Troy & Eastern.	.....do	1,472,000	1,472,000
Caseyville; East St. Louis & Suburban; St. Louis & O'Fallon.	.....do	1,007,347	1,007,347
Central Indiana; Centerville, Albia & Southern; Chicago Great Western; Interurban; Joplin & Pittsburg; Unspecified.	Indiana, Iowa, and Kansas.	552,593	552,593
Eastern Kentucky; Kentucky & Tennessee; Kentucky Midland; Louisville, Henderson & St. Louis; Morehead & North Fork; Ohio & Kentucky; Sandy Valley & Elkhorn.	Kentucky	2,552,231	2,552,231
Bevier & Southern; St. Louis & Hannibal	Missouri	515,107	515,107
El Paso & Southwestern; New Mexico Central; New Mexico Midland; Santa Fe, Raton & Eastern.	New Mexico	1,021,544	1,021,544
Hocking Sunday Creek Traction; Ohio River & Western; Ohio River Electric Ry. & Power Co.; Ohio Service Traction; Youngstown & Ohio River; Youngstown & Southern Electric; Unspecified.	Ohio	278,173	278,173
Tramway; West Side Belt	Pennsylvania	2,768,529	2,768,529
Buffalo & Susquehanna R. R. Corporation; Indiana County Street Rys. Co.; Rural Valley.	.....do	2,724,953	2,724,953
East Broad Top R. R. & Coal Co.; Juniata & Southern; Susquehanna & New York.	.....do	549,386	549,386
Altoona Northern; Johnstown & Stony Creek	.....do	158,818	158,818
New Haven & Dunbar; Ursina & North Fork; Washington Run.	.....do	213,843	213,843
Davidson, Hicks & Green; Morgan & Fentress; Tennessee.	Tennessee	39,984	39,984
Gulf, Texas & Western; Rio Grande & Eagle Pass; Texas & Pacific; Texas Short Line; Trinity & Brazos Valley.	Texas	968,347	968,347
Unspecified	Virginia	2,800	2,800
Centralia Eastern; Eastern Railway & Lumber Co.; Pacific Coast; Puget Sound & Willapa Harbor; Puget Sound Electric; Tacoma Eastern.	Washington	653,480	653,480
Buffalo Creek & Gauley; Cherry River Boom & Lumber Co.; Kanawha, Glen Jean & Eastern; Sewell Valley; West Virginia Midland.	West Virginia	1,223,646	1,223,646
Campbells Creek; Kanawha Central; West Virginia & Southern.	.....do	498,565	498,565
Total railroad shipments		414,475,002	414,475,002
Waterways.			
Kanawha River	West Virginia	1,082,349	1,082,349
Monongahela River	Pennsylvania	7,649,839	7,649,839
Ohio River	Indiana and West Virginia	53,786	429,812
	Kentucky	297,844	
	Ohio	78,182	
Warrior River	Alabama	44,335	44,335
Miscellaneous:			
Cook Inlet	Alaska		
Coquille River	Oregon		
Green River	Kentucky		35,348
Illinois River	Illinois		
Kentucky River	Kentucky		
Lake Watcom	Washington		
Total waterway shipments		9,191,683	9,191,683
Grand total		423,666,685	423,666,685

PRODUCTION OF COAL BY STATES.

In the preceding sections of this report the statistics covering the production of coal in the United States have been presented with the States as units but both the statistics and the coal industry have

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been discussed mainly with reference to the United States as a whole. It will be realized, however, that many of the inferences drawn from the figures in the aggregate do not apply with equal force when smaller units, such as individual States, are considered, and of course this is all the truer of the still smaller units, the counties constituting the States. In the following pages a brief review of the trade in each State is given in connection with detailed statistics of production by counties. For data regarding labor, strikes, accidents, use of mining machines and steam shovels, and coal-washing operations the reader is referred to the preceding pages.

ALABAMA.

The production of coal in Alabama in 1916 was 18,086,197 net tons, valued at $24,859,831, an increase, compared with 1915, of 3,158,260 tons, or 21 per cent, in quantity and of $5,793,788, or 30 per cent, in value. Two-thirds of this increase was in the coal used in the manufacture of coke, the total of which increased 2,098,162 tons [1] over 1915 as a result of the greatly increased activity of the iron and steel industry in the State.

The production of coal in Jefferson County increased more than 2,250,000 tons, in Walker County the increase was 710,000 tons, and in Tuscaloosa County, 153,200 tons.

A number of factors tended to hold down the production. In July and August abnormally heavy rains and floods caused a number of mines to shut down and greatly interfered with the operation of others. Several mine explosions caused the mines to close for longer or shorter periods. Although there was an exodus of labor to other fields and industries during the last half of the year and the supply of labor was reported to have been deficient throughout the coal fields, the number of men employed increased from 22,591 in 1915 to 25,308 in 1916. The most powerful influence affecting production, however, was the shortage of cars, which began to be felt as early as May and became acute in the last three months of the year.

The increase in the average number of days the mines were worked was notable, from 223 in 1915 to 262 in 1916, a gain of one and a half months' working time. In Tuscaloosa County the number of working days, 293, was almost the maximum possible.

The market for Alabama coal was materially widened in 1916. A readjustment of rates, effective in August, enlarged the market on the west in the Mississippi Valley region, and greater shipments than at any time in the past were made during the last half of the year to the Carolinas, West Virginia, Illinois, and points on the Pacific coast. In December it was announced that the business of the Pittsburgh Coal Co. at New Orleans, amounting to about 500,000 tons a year, had been taken over by Alabama interests, and that new mines were projected to take care of this and other new trade.

The average value of the coal produced in Alabama in 1916 was $1.37 per ton, compared with $1.28 in 1915, an increase that was shared by all producing counties. The average value of all shipments was $1.39 per ton; of coal sold locally, $1.48 per ton; of mine fuel $1.20 per ton; and of coal made into coke at the mines, $1.33 per ton.

[1] See current report on coke in Mineral Resources for 1916.

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Coal produced in Alabama in 1915 and 1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
1915.									
Bibb	1,420,639	8,359	105,536	.....	1,534,534	$2,093,131	$1.36	2,623	235
Blount	163,018	1,021	1,700	.....	165,739	226,716	1.37	368	189
Etowah	173,583	1,974	1,811	.....	177,368	259,332	1.46	325	289
Jefferson	5,884,992	329,456	197,806	1,167,249	7,579,503	9,658,836	1.27	10,129	235
Marion	62,653	1,275	4,962	.....	68,890	101,318	1.47	199	163
St. Clair	754,569	2,959	16,530	.....	774,058	946,446	1.22	786	252
Shelby	550,594	3,290	35,528	.....	589,412	989,580	1.68	1,058	227
Tuscaloosa	298,627	9,545	71,277	408,137	787,586	963,910	1.22	1,334	209
Walker	2,886,594	29,925	99,950	205,486	3,221,955	3,784,424	1.17	5,669	197
Winston	26,217	370	40	.....	26,627	38,919	1.46	80	191
Small mines[a]	1,000	1,065	200	.....	2,265	3,431	1.51	20	12
	12,222,486	389,239	535,340	1,780,872	14,927,937	19,066,043	1.28	22,591	223

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
1916.									
Bibb	1,364,206	12,281	97,370	.....	1,493,856	2,142	411	2,553	255
Blount and Jackson	207,986	2,875	1,250	.....	212,111	389	36	425	240
Etowah	154,474	2,163	1,964	.....	158,601	281	54	335	269
Jefferson	7,428,469	303,661	268,133	1,834,606	9,834,869	10,869	1,793	12,662	275
Marion	68,083	6,021	6,054	.....	80,158	180	41	221	215
St. Clair	765,485	3,403	23,282	.....	792,170	787	110	897	250
Shelby	578,551	9,705	30,382	.....	618,638	938	204	1,142	270
Tuscaloosa	272,307	8,859	59,270	600,360	940,796	1,042	240	1,282	293
Walker	3,540,791	40,744	99,506	250,982	3,932,023	4,739	955	5,694	235
Winston	22,005	410	.....	.....	22,415	86	11	97	143
Small mines	.....	560	.....	.....	560	.....	.....	.....	.....
	14,422,356	390,682	587,211	2,685,948	18,086,197	21,453	3,855	25,308	262

[a] Includes Jackson County.

Value of coal produced in Alabama in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Bibb	$2,032,201	$23,303	$101,946	.....	$2,157,450	1.44
Blount and Jackson	298,204	3,931	1,725	.....	303,860	1.43
Etowah	243,471	3,598	3,222	.....	250,291	1.58
Jefferson	10,447,149	443,775	362,917	$2,485,957	13,739,798	1.40
Marion	121,123	8,604	6,054	.....	135,781	1.69
St. Clair	1,018,356	4,904	26,132	.....	1,049,392	1.32
Shelby	1,076,722	17,555	33,707	.....	1,127,984	1.82
Tuscaloosa	359,799	21,976	68,151	754,352	1,204,278	1.28
Walker	4,376,689	49,231	102,025	319,255	4,847,200	1.23
Winston	41,332	825	.....	.....	42,157	1.88
Small mines	.....	1,640	.....	.....	1,640	2.93
	20,015,046	579,342	705,879	3,559,564	24,859,831	1.37
Average value per ton	1.39	1.48	1.20	1.33	1.37	.....

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In the following table comparative statistics are given covering five years' annual production of coal in Alabama, by counties:

Coal produced in Alabama, 1912–1916, in net tons.

County.	1912	1913	1914	1915	1916	Increase or decrease, 1916.
Bibb	1,781,335	1,911,026	1,674,846	1,534,534	1,493,856	− 40,678
Blount	146,342	178,958	150,384	165,739	[a] 212,111	+ 46,372
Cullman, Jackson, and Marion	131,505	123,615	81,041	[b] 68,890	[b] 80,158	+ 11,268
Etowah	171,308	137,792	156,909	177,368	158,601	− 18,767
Jefferson	8,174,849	9,028,834	7,936,145	7,579,503	9,834,869	+ 2,255,366
St. Clair	749,753	890,379	752,588	774,058	792,170	+ 18,112
Shelby	496,949	497,569	496,914	589,412	618,638	+ 29,226
Tuscaloosa	880,967	917,305	858,899	787,586	940,796	+ 153,210
Walker	3,547,962	3,967,263	3,450,185	3,221,955	3,932,023	+ 710,068
Winston	18,730	24,951	31,618	26,627	22,415	− 4,212
Small mines	900	830	1,893	[a] 2,265	560	− 1,705
Total	16,100,600	17,678,522	15,593,422	14,927,937	18,086,197	+ 3,158,260
Total value	$20,829,252	$23,083,724	$20,849,919	$19,066,043	$24,859,831	+$5,793,788

[a] Includes Jackson County. [b] Marion County only.

ALASKA.

In 1916 about 13,000 net tons of coal, valued at $55,000, was mined in Alaska; in 1915 the output was 1,400 tons, valued at $3,300. Most of the coal mined in 1916 came from the Doherty mine, in the Matanuska field; from the Bluff Point mine, on Cook Inlet; and from the Short Creek mine, in the Yentna district. Some coal was also taken from the La Duke mine, in the Matanuska field, and from the McDonald mine, in the Bering River field. A little coal was mined on Chicago Creek, in Seward Peninsula, and one small shipment of coal was made to Nome from the Corwin mine, in the Cape Lisburne field.

The most important event of the year to the Alaskan coal industry was the opening of the Bering River and Matanuska fields for leasing under the new law. These two fields were subdivided into leasing units by the Bureau of Mines in 1915. In 1916 the Geological Survey made a detailed geologic survey of the western part of the Nenana coal field, thus acquiring the information necessary for subdividing this field into leasing units. The United States Department of the Interior has received applications for leases in both the Matanuska and Bering River fields. The lower end of the Matanuska field was reached by the Government railroad in the summer of 1916, and an extension of the line into the heart of the field is now being built. It is also hoped that the Nenana field may be made accessible by railroad at an early date. This will make it possible to supply Fairbanks and other Yukon camps with the cheap fuel urgently needed by the gold mining industry. The small amount of coal produced at the McDonald mine, on Bering Lake, in the Bering River field, was sold in a local market. A survey was made and some construction work was done on a railroad to be built from Goose Point, on Bering River, to Canyon Creek, in the Bering River field. Goose Point is accessible to barges from Controller Bay by way of the lower reaches of Bering River, which is a tidal estuary. This railroad will be about 17 miles in length and is intended for coal traffic.

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The subjoined table shows the coal consumption of Alaska, including both imports and local production, since 1899. Most of the coal used up to 1916 was lignite. There was in 1906 a small production of bituminous coal from the seaward end of the Bering River field. The table does not include 855 tons of coal mined in the Bering River field in 1912 and 1,100 tons mined in the Matanuska field in 1913 for test by the United States Navy. Most of the coal shipped to Alaska is bituminous, but a little is anthracite.

Coal consumed in Alaska, 1899 to 1916, in short tons.

Year.	Imported from States, chiefly bituminous from Washington.	Produced in Alaska, chiefly subbituminous and lignite.	Total domestic, chiefly from Washington.	Total foreign coal, chiefly bituminous from British Columbia.a	Total coal consumed.
1899	10,006	1,200	11,200	50,120	61,320
1900	15,048	1,200	16,248	56,623	72,871
1901	24,000	1,300	25,300	77,674	102,974
1902	40,000	2,212	42,212	68,363	110,575
1903	64,626	1,447	66,073	60,605	126,678
1904	36,689	1,694	38,383	76,815	115,198
1905	67,713	3,774	71,487	72,567	144,054
1906	69,493	5,541	75,034	47,590	122,624
1907	46,246	10,139	56,385	88,596	144,981
1908	23,893	3,107	27,000	72,831	99,831
1909	33,112	2,800	35,912	74,316	110,228
1910	32,138	1,000	33,138	73,904	107,042
1911	32,255	900	33,155	88,573	121,728
1912	27,767	355	28,122	59,804	87,926
1913	61,666	2,300	63,966	60,600	124,566
1914	41,509	.....	41,509	21,882	63,391
1915	46,329	1,400	47,729	36,878	84,607
1916	44,934	13,073	58,007	36,454	94,461
	717,418	53,442	770,860	1,124,195	1,895,055

a By fiscal years ending June 30.

With the opening of the high-grade coal deposits of the Bering River and Matanuska fields the question of a market for these fuels becomes important. This matter was discussed at some length in a Survey publication issued several years ago.[1] The general analysis of the fuel market on the Pacific seaboard there presented still holds true. Time has not been available, however, to collect the necessary data on which to base an estimate of the present market for Alaskan coal. Since 1910 the consumption of coal in Alaska has declined, owing to an increased use of oil.

ARKANSAS.

Total production in Arkansas in 1916, 1,994,915 net tons; spot value, $3,836,845. The record for 1916 shows an increase of 342,809 tons, or 21 per cent, in quantity and $886,389, or 30 per cent, in value. The increase was largely in Sebastian County, although Franklin, Johnson, and Logan counties had a higher percentage of increase. The average value of the coal increased from $1.79 per ton in 1915 to $1.92 in 1916, each county recording an increase in this regard.

The number of men employed was slightly greater in 1916 than in 1915—3,772 compared with 3,751 men—and the number of days

[1] Brooks, A. H., Alaska coal and its utilization: U. S. Geol. Survey Bull. 442, pp. 47–100, 1910; reprinted as Bull. 442-J, 1914.

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worked increased from 149 in 1915 to 184 in 1916, notwithstanding that the total days' labor lost by reason of strikes and labor troubles was more than 30,000 in 1916, against 20,304 in 1915.

Coal produced in Arkansas in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Franklin	178,955	4,834	6,448	190,237	$333,551	$1.75	349	154
Johnson	161,899	6,775	7,783	176,457	418,229	2.37	691	108
Logan	28,601	250	654	29,505	54,984	1.86	138	111
Sebastian	1,087,995	22,366	43,133	1,153,494	1,838,798	1.59	2,284	154
Other counties [a]	86,221	3,139	4,157	93,517	286,171	3.06	289	221
Small mines	.....	8,896	.....	8,896	18,723	2.10	.....	.....
	1,543,671	46,260	62,175	1,652,106	2,950,456	1.79	3,751	149

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Franklin	230,458	4,131	8,529	243,118	303	46	349	225
Johnson	222,031	14,124	7,619	243,774	541	202	743	140
Logan	38,720	2,117	1,291	42,128	126	21	147	154
Sebastian	1,292,787	11,380	48,235	1,352,402	1,880	350	2,230	186
Other counties [a]	97,109	2,782	3,882	103,773	205	98	303	239
Small mines	.....	9,720	.....	9,720	.....	.....	.....	.....
	1,881,105	44,254	69,556	1,994,915	3,055	717	3,772	184

[a] Pope, Scott, and Washington.

Value of coal produced in Arkansas in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Franklin	$420,114	$10,659	$11,489	$442,262	$1.82
Johnson	575,476	31,091	15,079	621,646	2.55
Logan	99,616	3,735	1,541	104,892	2.49
Sebastian	2,220,929	23,972	61,424	2,306,325	1.71
Other counties [a]	321,838	10,781	6,794	339,413	3.27
Small mines	.....	22,307	.....	22,307	2.29
	3,637,973	102,545	96,327	3,836,845	1.92
Average value per ton	1.93	2.32	1.38	1.92	.....

[a] Pope, Scott, and Washington.

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Coal produced in Arkansas 1912–1916, in net tons.

County.	1912	1913	1914	1915	1916	Increase or decrease, 1916.
Franklin	378,314	346,682	163,746	190,237	243,118	+ 52,881
Johnson	192,326	166,208	148,845	176,457	243,774	+ 67,317
Logan	15,272	(a)	7,172	29,505	42,128	+ 12,623
Pope, Scott, and Washington	b 65,416	b c 85,136	d 88,047	93,517	103,773	+ 10,256
Sebastian	1,454,128	1,635,379	1,423,202	1,153,494	1,352,402	+ 198,908
Small mines	363	702	528	8,896	9,720	+ 824
Total	2,100,819	2,234,107	1,836,540	1,652,106	1,994,915	+ 342,809
Total value	$3,582,789	$3,923,701	$3,158,168	$2,950,456	$3,836,845	+$886,389

a Included with Pope and other counties.
b No production in Scott County.
c Includes Logan County.
d Includes Ouachita County.

CALIFORNIA, IDAHO, AND NEVADA.

The statistics of the production of coal in California in 1910 to 1913, in California, Idaho, and Nevada in 1914 and 1915, and in California and Idaho in 1916, are given in the following table. In 1916 no coal was produced in Nevada and only one mine was reported to have operated in California and two mines in Idaho.

Coal produced in California, 1910–1913, in California, Idaho, and Nevada in 1914 and 1915, and in California and Idaho in 1916.

Year.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
1910	6,679	3,985	500	11,164	$18,336	$1.64	14	192
1911	4,981	5,266	500	10,747	16,097	1.50	45	254
1912	3,748	3,630	3,600	10,978	23,601	2.15	52	184
1913	14,864	1,808	8,167	24,839	84,073	3.38	35	332
1914 a	4,200	9,174	600	13,974	39,821	2.85	43	291
1915 a	2,488	9,715	300	12,503	32,054	2.56	36	285
1916 b	1,593	4,647	1,000	7,240	15,367	2.12	18	188

a Includes Idaho and Nevada.
b Includes Idaho.

COLORADO.

The production of coal in Colorado in 1916 was 10,484,237 net tons, valued at $16,964,104, an increase of 1,859,257 tons, or nearly 22 per cent, in quantity and of $3,364,840, or 25 per cent, in value. The output in 1916 was the largest since 1912, but was exceeded in 1907, 1909, 1910, and 1912, in the seven very prosperous years for the coal industry of Colorado, from 1906 to 1912. The largest single factor in the increase in 1916 was the demand for coke by the iron and steel plants of the Colorado Fuel & Iron Co., at Pueblo, and by the base-metal smelters in the West. The increase in the quantity of coal made into coke in Colorado was more than 700,000 tons, or about 38 per cent of the total increase. A general widening of markets for coal from Colorado and greater use by industries within the State, as well as large consumption by railroads, account for the remainder of the increase in 1916. The Routt County field

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made a substantial gain, its coal finding a ready market in Denver and in Nebraska.

A car shortage developed about the 1st of October, but it was not severe compared with that in other parts of the country or with similar shortages in the State in previous years. The so-called lignite fields in the northeastern part of Colorado suffered most because of lack of cars. The coal fields in that region are adjacent to a large agricultural district, and the movement of sugar beets, potatoes, and other foodstuffs in the fall and early part of the winter required cars that normally would have been available for coal.

The supply of labor was in general adequate. The total number of men employed in 1916 was 13,104 compared with 12,372 in 1915. The working time showed a gain from 194 days in 1915 to 233 in 1916. The mines in Las Animas County, the largest producer in the State, worked nearly full time—283 days in 1916, compared with 212 in 1915. The average annual production per man was 800 tons in 1916 against 697 in 1915 and 809 in 1914. Labor disturbances in 1916 were almost entirely absent.

The average value per ton increased from $1.58 to $1.62, 4 cents, or 2.5 per cent.

The output of Las Animas County, nearly one-half of which is made into coke at the mines and the other half largely sold to railroads and steam plants under contract, was sold for the same average return as in 1915. The output from Boulder, Fremont, and Routt counties, which enters largely into domestic trade, brought average returns from 6 to 13 cents greater in 1916 than in 1915. The average value per ton at the mines of all shipments of coal in Colorado in 1916 was $1.69 and of local sales $1.67.

Coal produced in Colorado in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Total value	Average value per ton.	Number of employees.	Average number of days worked.
Archuleta and Montezuma	1,775	600	.....	.....	2,375	$6,038	$2.54	7	196
Boulder	895,299	16,758	34,831	.....	946,888	1,483,840	1.57	1,080	183
Delta	61,472	7,281	300	.....	69,053	106,980	1.55	91	132
El Paso	179,300	110,390	10,193	.....	299,883	442,161	1.47	312	222
Fremont	444,962	18,336	9,986	.....	473,284	986,797	2.08	974	148
Garfield	126,609	3,809	8,975	.....	139,393	211,305	1.52	165	221
Gunnison	413,057	2,587	22,517	1,242	439,403	694,236	1.58	563	166
Huerfano	1,605,870	19,683	56,782	.....	1,682,335	2,786,069	1.66	2,857	196
Jackson and Jefferson	139,604	2,918	9,976	.....	152,498	207,306	1.36	252	146
La Plata	84,008	18,292	1,398	13,804	117,502	206,109	1.75	151	201
Las Animas	1,745,838	24,341	83,368	1,000,300	2,853,847	4,037,592	1.41	4,030	212
Mesa	72,142	26,185	3,000	.....	101,327	145,461	1.44	155	153
Pitkin and Rio Blanco	45,294	1,506	5,343	.....	52,143	79,838	1.53	82	159
Routt	823,560	5,425	23,330	.....	852,315	1,569,174	1.84	1,089	220
Weld	385,030	22,899	24,572	.....	432,501	618,296	1.43	564	157
Small mines	.....	10,233	.....	.....	10,233	18,062	1.77	.....	.....
	7,023 820	291,243	294,571	1,015,346	8,624,980	13,599,264	1.58	12,372	194

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Coal produced in Colorado in 1915 and 1916—Continued.

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Boulder	1,002,304	24,908	30,332	.....	1,057,539	906	179	1,085	204
Delta	60,239	10,157	300	.....	70,696	55	20	75	159
El Paso	195,497	110,205	6,968	.....	312,670	298	39	337	223
Fremont	543,997	48,588	12,523	.....	605,108	1,060	155	1,215	166
Garfield	121,404	5,892	6,475	.....	133,771	102	64	166	176
Gunnison	454,241	5,121	21,808	31,100	512,265	449	138	587	223
Huerfano	1,790,145	49,846	44,952	.....	1,884,943	2,277	646	2,923	218
Jackson and Jefferson	174,513	2,969	8,222	.....	185,704	163	38	201	218
La Plata	78,516	15,328	1,206	13,558	108,608	115	23	138	208
Las Animas	2,196,844	45,364	86,830	1,713,899	4,042,937	3,650	898	4,548	283
Mesa	116,397	15,714	.....	.....	132,111	119	35	154	195
Pitkin and Rio Blanco	28,063	9,684	5,094	.....	42,861	58	18	76	177
Routt	881,568	6,957	26,503	.....	915,028	697	258	955	219
Weld	414,072	30,611	20,276	.....	464,959	505	137	642	204
Small mines a	.....	15,042	.....	.....	15,042	2	.....	2	200
	8,057,820	396,376	271,484	1,758,557	10,484,237	10,456	2,648	13,104	223

a Includes Montezuma County.

Value of coal produced in Colorado in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Boulder	$1,632,729	$53,839	$32,875	.....	$1,719,443	$1.63
Delta	110,000	18,527	.....	.....	128,527	1.82
El Paso	284,053	166,969	8,131	.....	459,153	1.47
Fremont	1,206,368	91,021	18,393	.....	1,316,282	2.18
Garfield	188,338	11,262	5,828	.....	205,478	1.54
Gunnison	733,080	8,681	27,146	$44,566	813,423	1.59
Huerfano	3,291,122	58,157	47,015	.....	3,396,294	1.80
Jackson and Jefferson	257,323	7,770	6,102	.....	271,695	1.46
La Plata	127,224	38,134	2,034	33,895	201,287	1.86
Las Animas	3,254,065	69,095	115,955	2,254,005	5,693,120	1.41
Mesa	170,620	34,888	.....	.....	205,508	1.56
Pitkin and Rio Blanco	42,640	14,222	8,717	.....	65,579	1.53
Routt	1,771,302	13,641	21,086	.....	1,806,029	1.97
Weld	587,280	47,018	20,334	.....	654,632	1.41
Small mines a	.....	26,954	.....	.....	26,954	1.79
	13,657,844	660,178	313,616	2,332,466	16,964,104	1.62
Average value per ton	1.69	1.67	1.16	1.33	1.62	.....

a Includes Montezuma County.

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Coal produced in Colorado, 1912–1916, in net tons.

County.	1912	1913	1914	1915	1916	Increase or decrease, 1916.
Archuleta and Montezuma	2,500	(a)	3,775	2,375	.....	− 2,375
Boulder	1,054,925	902,918	1,000,590	946,888	1,057,539	+ 110,651
Delta	75,043	80,464	86,861	69,053	70,696	+ 1,643
El Paso	334,904	326,899	280,577	299,883	312,670	+ 12,787
Fremont	738,833	535,778	169,271	473,284	605,108	+ 131,824
Garfield	185,452	158,662	112,842	139,393	133,771	− 5,622
Gunnison	557,685	472,753	402,045	439,403	512,265	+ 72,862
Huerfano	1,899,538	1,705,240	1,724,265	1,682,335	1,884,943	+ 202,608
Jackson and Jefferson	145,103	219,569	188,080	152,498	185,704	+ 33,206
La Plata	132,487	140,055	132,317	117,502	108,603	− 8,899
Las Animas	4,708,698	3,739,357	2,663,288	2,853,847	4,042,937	+ 1,189,090
Mesa	114,493	134,438	163,894	101,327	132,111	+ 30,784
Pitkin and Rio Blanco	(b)	54,517	65,104	52,143	42,861	− 9,282
Routt	448,261	334,961	666,384	852,315	915,028	+ 62,713
Weld	491,037	409,131	475,734	432,501	464,959	+ 32,458
Small mines c	88,865	11,768	5,532	10,233	15,042	+ 4,809
Total	10,977,824	9,232,510	8,170,559	8,624,980	10,484,237	+ 1,859,257
Total value	$16,345,336	$14,035,090	$13,601,718	$13,599,264	$16,964,104	+$3,364,840

a Archuleta County included with small mines; no production in Montezuma County.
b Pitkin County included with small mines; no production in Rio Blanco County.
c Includes in 1911 to 1913 counties as indicated above.

GEORGIA.

Total production in 1916, 173,554 net tons; spot value, $310,093.

The output of coal in Georgia in 1916 was 39,058 tons, or 29 per cent, more in quantity and $78,232, or 34 per cent, greater in value than in 1915. The increase in the total was in the quantity of coal made into coke, as shipments of coal decreased.

Coal produced in Georgia, 1914, 1915, and 1916.

Year.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
1914	85,645	1,400	7,900	45,298	140,243	$239,462	$1.71	355	207
1915	90,523	1,396	7,200	35,377	134,496	231,861	1.72	368	197
1916	76,954	1,672	7,200	87,728	173,554	310,093	1.79	411	280

ILLINOIS.

The production of coal in Illinois in 1916 was 66,195,336 net tons, an increase of 7,365,760 tons, or 12.5 per cent. The value of the coal produced was $82,457,954, an increase of $17,835,483, or 27.6 per cent. That the output was not greater, in view of the active demand for coal throughout the latter part of the year is attributed to lack of cars and, in some localities, to scarcity of labor. In general throughout the State the demand was good and production above the normal in January, February, and March, but in April there was a decided drop in mining activity, and in May, June, and July the rate of production was below that established in the first quarter, with many mines idle because of lack of markets for their

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product. About the middle of August tne demand became stronger, and by the middle of September it was active, and car shortage was reported in several districts. October was the best month as regards output in the second half of the year, for the shortage of cars became more and more evident toward the end of the year, and in nearly all districts curtailed the output of the mines in November and particularly in December. The northern fields had decreased production, as did also Saline County, in the extreme southern part of the State. The fields in the region about St. Louis, Mo., and in Franklin and Williamson counties, all showed substantial increase.

The experience of the producing companies with regard to car supply differed, of course, according to the railroads which served them, for some roads were more able than others to meet the unprecedented demands for cars. Operators in the district about St. Louis reported a shortage of cars as early as May. In other parts of the State the supply of cars was ample until the end of December, but if the State is considered as a whole it appears that the car shortage did not begin to be serious until the latter part of October, was at its worst in November, and, though acute, decreased somewhat in a few districts in December.

It is not possible to state what the production might have been if the railroads had been able to move all the coal that was offered. It appears that even aside from the lack of cars a shortage of labor would have acted as a brake on production, for in some of the counties there was a scarcity of men almost as great as that of cars. The number of men employed at the coal mines and the average number of days worked were both below the normal in Illinois in 1915, and in 1916 the number of men was about the same as in 1915, but the average days worked increased from 179 to 198, a good record for the State. The opening of mines that had been closed for a time and the more active operation of others, however, resulted in a need for more men than were available. As the result of an increase of nearly 2 per cent in the average daily output per man and an increase of 19 days, or more than 10 per cent, in the working time, the average annual output per man increased 778 tons to 876 tons, nearly 100 tons per year per man in 1916 over 1915.

The most notable feature of the year was the extension of the markets for Illinois coal. In the past little of the coal mined in Illinois has been used east of the Chicago district. In the last half of 1916, because of the unsatisfied demand for coal in the Eastern States, coal from Illinois was shipped in considerable quantity to Michigan, to Ohio, and to Buffalo, and other New York points as industrial and railroad fuel. Illinois coal was also sold in Cincinnati and in Mississippi. The normal movement of coal from Illinois to Wisconsin, Minnesota, and neighboring States was augmented by a demand for supplies to take the place of eastern coal, which for the time could not be obtained.

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Coal produced in Illinois in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons.)	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Bond, Jefferson, Washington, and White	451,730	44,970	17,005	513,705	$523,530	$1.02	666	141
Bureau	1,119,424	34,862	48,412	1,202,698	1,961,127	1.63	3,084	186
Christian	2,010,396	81,600	43,056	2,135,052	2,207,686	1.03	2,699	181
Clinton	1,257,928	14,996	42,734	1,315,648	1,239,047	.94	1,268	202
Franklin	7,767,990	52,272	207,511	8,027,773	8,813,376	1.10	9,054	171
Fulton	1,749,714	48,219	51,973	1,849,906	2,267,157	1.23	3,143	174
Gallatin	62,025	10,371	4,984	77,380	62,700	.81	159	124
Greene	.....	5,748	16	5,764	11,300	1.96	20	181
Grundy	267,581	9,154	16,925	293,660	428,414	1.46	752	175
Hancock, Morgan, Scott, and Warren	.....	3,924	.....	3,924	8,491	2.16	17	142
Henry	.....	43,839	2,280	46,219	90,373	1.96	100	221
Jackson	635,519	17,070	29,453	682,042	919,382	1.35	733	191
Knox	.....	11,535	450	11,985	22,287	1.86	35	179
La Salle	720,221	418,306	54,267	1,192,794	2,101,188	1.76	2,254	197
Livingston	8,928	53,913	500	63,341	110,367	1.74	90	196
Logan	237,458	53,501	20,387	311,346	407,070	1.31	652	160
McDonough	500	4,382	250	5,132	11,223	2.19	22	158
McLean, Marshall, Putnam, and Woodford	1,059,322	172,969	63,946	1,296,237	2,160,315	1.67	2,934	222
Macon and Moultrie	194,784	121,536	13,170	329,490	498,363	1.51	533	184
Macoupin	4,663,147	48,940	120,453	4,832,540	4,638,945	.96	5,311	168
Madison	3,251,828	95,825	72,302	3,419,955	3,355,763	.98	3,730	165
Marion	890,008	9,385	25,882	925,365	879,840	.95	1,139	196
Menard	51,478	25,753	1,062	78,893	100,455	1.27	232	112
Mercer	318,481	8,468	13,891	340,840	495,732	1.45	509	207
Montgomery	2,814,907	19,922	42,630	2,877,459	2,952,009	1.03	3,051	191
Peoria	1,087,864	85,340	20,147	1,193,351	1,472,948	1.23	1,534	196
Perry	2,302,398	36,191	45,069	2,383,658	2,357,064	.99	2,613	205
Randolph	846,817	28,277	17,354	892,948	886,844	.99	1,122	182
Rock Island	.....	24,041	706	24,747	43,510	1.76	68	130
St. Clair	2,635,062	165,320	107,747	2,908,129	2,597,864	.89	3,864	136
Saline	4,063,483	31,485	71,231	4,166,249	4,414,601	1.06	5,004	179
Sangamon	4,676,786	285,375	113,062	5,075,823	5,290,177	1.04	6,563	175
Schuyler	.....	5,864	.....	5,864	7,918	1.35	17	213
Shelby	70,834	12,693	5,145	88,672	126,458	1.43	302	89
Stark	40	11,679	200	11,919	23,772	1.99	33	205
Tazewell	202,061	56,734	4,452	263,247	330,363	1.25	454	180
Vermilion	2,261,238	152,569	55,456	2,469,263	2,754,147	1.12	2,826	198
Will	116,283	18,233	6,900	141,416	243,757	1.72	359	197
Williamson	7,030,068	44,116	190,211	7,264,395	7,550,097	1.04	8,664	182
Small mines	.....	100,747	.....	100,747	166,811	1.66	.....	.....
	54,826,393	2,470,114	1,533,069	58,829,576	64,622,471	1.10	75,610	179

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Coal produced in Illinois in 1915 and 1916—Continued.

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Bond and White	113,882	14,042	4,995	132,919	162	31	193	173
Bureau	1,258,151	43,613	38,254	1,340,018	2,470	197	2,667	230
Christian	2,348,261	123,618	44,457	2,516,336	2,774	225	2,999	187
Clinton	1,184,476	79,799	43,437	1,307,712	1,426	128	1,554	168
Franklin	9,095,314	58,813	234,165	9,388,292	7,739	987	8,726	198
Fulton	2,023,749	107,294	59,907	2,190,950	2,755	266	3,021	198
Gallatin and Johnson	61,962	6,331	2,005	70,298	56	8	64	134
Greene	.....	2,953	10	2,963	14	5	19	119
Grundy	289,914	17,062	17,818	324,794	663	64	727	205
Hancock, Scott, and Warren	.....	8,036	110	8,146	22	5	27	177
Henry	.....	42,157	2,345	44,502	73	15	88	242
Jackson	654,142	95,764	22,882	772,788	871	90	961	221
Knox	16	9,556	325	9,897	23	3	26	236
La Salle	676,474	332,236	42,190	1,050,900	1,716	236	1,952	201
Livingston	27,174	80,215	3,320	110,709	130	44	174	243
Logan	354,280	87,728	23,151	465,159	577	64	641	202
McDonough	350	13,277	300	13,927	19	3	22	173
McLean, Marshall, Putnam, Will, and Woodford	1,176,576	202,144	69,153	1,447,873	2,707	250	2,957	247
Macon and Moultrie	236,004	148,401	12,168	396,573	493	77	570	231
Macoupin	5,296,014	70,629	125,573	5,492,216	5,218	440	5,658	194
Madison	3,999,467	97,660	76,460	4,173,587	3,576	322	3,898	195
Marion	954,473	15,871	28,765	999,109	947	103	1,050	220
Menard	122,494	32,610	4,232	159,336	185	24	209	201
Mercer	241,307	19,814	13,571	274,692	312	53	365	232
Montgomery	3,013,211	22,471	40,030	3,075,712	2,888	383	3,271	185
Peoria	1,189,229	104,854	13,817	1,307,900	1,359	171	1,530	224
Perry	2,319,811	95,933	58,829	2,474,573	2,267	219	2,486	193
Randolph	915,117	31,018	18,964	965,089	1,077	106	1,183	186
Rock Island	.....	32,629	951	33,580	66	12	78	158
St. Clair	3,765,653	273,396	133,648	4,172,697	4,467	467	4,934	169
Saline	4,023,759	46,883	82,874	4,153,516	3,708	322	4,030	192
Sangamon	4,740,471	263,498	125,001	5,128,970	5,803	466	6,269	179
Schuyler	.....	8,115	.....	8,115	23	4	27	189
Shelby	61,815	13,523	2,935	78,273	104	23	127	172
Stark	150	7,613	250	8,013	23	7	30	132
Tazewell	322,332	58,544	4,735	385,611	425	42	467	240
Vermilion	2,601,830	186,465	45,614	2,833,909	2,751	467	3,218	213
Washington	617,660	60,135	16,673	694,468	583	43	626	232
Williamson	7,800,824	67,870	208,933	8,077,627	7,655	1,039	8,694	198
Small mines	.....	103,587	.....	103,587	.....	.....	.....	.....
	61,486,342	3,086,157	1,622,837	66,195,336	68,127	7,411	75,538	198

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Value of coal produced in Illinois in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Bond and White	$164,053	$23,832	$5,485	$193,370	$1.45
Bureau	2,248,042	77,689	46,054	2,371,785	1.77
Christian	2,598,340	195,259	42,207	2,835,806	1.13
Clinton	1,233,943	103,656	41,856	1,379,455	1.05
Franklin	12,283,591	106,363	201,033	12,590,987	1.34
Fulton	2,928,287	201,667	66,904	3,196,858	1.46
Gallatin and Johnson	123,924	10,987	3,000	137,911	1.96
Greene	.....	6,066	20	6,086	2.05
Grundy	586,579	45,118	26,720	658,417	2.03
Hancock, Scott, and Warren	.....	19,574	40	19,614	2.41
Henry	.....	82,916	2,451	85,367	1.92
Jackson	803,993	130,833	18,348	953,174	1.23
Knox	32	18,168	325	18,525	1.87
La Salle	1,230,604	671,553	53,057	1,955,214	1.86
Livingston	32,608	137,245	3,619	173,472	1.57
Logan	492,986	159,669	23,159	675,814	1.45
McDonough	613	29,309	.....	29,922	2.15
McLean, Marshall, Putnam, Will, and Woodford	2,063,486	468,891	86,771	2,619,148	1.81
Macon and Moultrie	328,323	305,142	11,424	644,889	1.63
Macoupin	5,539,922	127,427	97,440	5,764,789	1.05
Madison	4,264,913	151,043	71,789	4,487,745	1.08
Marion	1,011,306	24,256	26,386	1,061,948	1.06
Menard	188,231	60,525	5,494	254,250	1.60
Mercer	379,543	41,390	20,678	441,611	1.61
Montgomery	3,504,781	48,456	35,484	3,588,721	1.17
Peoria	1,538,420	182,071	17,097	1,737,588	1.33
Perry	2,546,402	147,575	50,221	2,744,198	1.11
Randolph	1,030,403	39,981	18,427	1,088,811	1.13
Rock Island	.....	60,173	1,596	61,769	1.84
St. Clair	4,078,605	361,940	121,043	4,561,588	1.09
Saline	4,816,602	74,501	74,667	4,965,770	1.20
Sangamon	5,794,781	433,358	113,082	6,341,221	1.24
Schuyler	.....	17,230	.....	17,230	2.12
Shelby	82,139	31,250	2,935	116,324	1.49
Stark	75	15,986	125	16,186	2.02
Tazewell	447,718	88,316	4,632	540,666	1.40
Vermilion	3,210,195	242,261	51,474	3,503,930	1.24
Washington	713,537	76,112	18,966	808,615	1.16
Williamson	9,299,109	111,175	211,460	9,621,744	1.19
Small mines	.....	187,436	.....	187,436	1.81
	75,566,086	5,316,399	1,575,467	82,457,954	1.25
Average value per ton	1.23	1.72	0.97	1.25	.....

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Coal produced in Illinois, 1912–1916, in net tons.

County.	1912	1913	1914	1915	1916	Increase or decrease, 1916.
Bond, Jefferson, Washington, and White	[a] 526,690	600,460	661,892	513,705	[b] 827,387	+ 313,682
Bureau	1,677,317	1,639,208	1,284,311	1,202,698	1,340,018	+ 137,320
Christian	1,467,846	1,504,716	1,486,053	2,135,052	2,516,336	+ 381,284
Clinton	1,040,479	1,049,575	3,090,787	1,315,648	1,307,712	− 7,936
Franklin	4,442,284	6,072,102	7,311,209	8,027,773	9,388,292	+ 1,360,519
Fulton	2,453,424	2,388,775	2,052,170	1,849,906	2,190,950	+ 341,044
Gallatin	64,244	46,105	81,735	77,380	[c] 70,298	− 7,082
Greene	7,841	(d)	6,665	5,764	2,963	− 2,801
Grundy	540,787	401,527	388,368	293,660	324,794	+ 31,134
Hancock, Morgan, Schuyler, Scott, and Warren	[e] 11,054	[d e] 12,069	7,169	9,788	[f] 16,261	+ 6,473
Henry	58,613	43,383	47,010	46,219	44,502	− 1,717
Jackson	703,190	723,863	601,697	682,042	772,788	+ 90,746
Knox	22,293	18,280	14,150	11,985	9,897	− 2,088
La Salle	1,537,591	1,564,459	1,279,592	1,192,794	1,050,900	− 141,894
Livingston	65,774	63,877	64,461	63,341	110,709	+ 47,368
Logan	466,528	351,666	352,181	311,346	465,159	+ 153,813
McDonough	14,446	12,603	5,251	5,132	13,927	+ 8,795
McLean, Putnam, and Woodford	995,328	994,997	853,941	[g] 1,296,237	[h] 1,447,873	+ 10,220
Macon and Moultrie	372,570	326,274	363,987	329,490	396,573	+ 67,083
Macoupin	4,986,574	5,097,619	4,555,834	4,832,540	5,492,216	+ 659,676
Madison	4,025,878	3,732,153	3,546,256	3,419,955	4,173,587	+ 753,632
Marion	1,311,024	988,964	906,837	925,365	999,109	+ 73,744
Marshall	449,660	426,490	383,331	(g)	(h)	.....
Menard	177,578	120,174	76,603	78,893	159,336	+ 80,443
Mercer	393,018	408,875	372,528	340,840	274,692	− 66,148
Montgomery	2,182,823	2,689,702	2,597,677	2,877,459	3,075,712	+ 198,253
Peoria	1,225,574	1,163,073	1,055,323	1,193,351	1,307,900	+ 114,549
Perry	1,444,114	2,013,128	2,236,480	2,383,658	2,474,573	+ 90,915
Randolph	798,163	763,472	956,582	892,948	965,089	+ 72,141
Rock Island	66,817	35,672	36,022	24,747	33,580	+ 8,833
St. Clair	4,734,840	4,383,459	3,246,322	2,908,129	4,172,697	+ 1,264,568
Saline	4,417,874	4,189,003	3,746,656	4,166,249	4,153,516	− 12,733
Sangamon	5,714,742	5,875,853	5,679,595	5,075,823	5,128,970	+ 53,147
Shelby	185,501	193,632	196,339	88,672	78,273	− 10,399
Stark	34,176	14,610	12,703	11,919	8,013	− 3,906
Tazewell	271,321	341,626	335,566	263,247	385,611	+ 122,364
Vermilion	3,434,923	3,501,880	2,394,081	2,469,263	2,833,909	+ 364,646
Will	130,806	149,926	136,758	[h] 141,416	(h)	(h)
Williamson	7,354,507	7,644,397	7,066,029	7,264,395	8,077,627	+ 813,232
Small mines	77,014	71,097	99,046	100,747	103,587	+ 2,840
Total	59,885,226	61,618,744	57,589,197	58,829,576	66,195,336	+ 7,365,760
Total value	$70,294,338	$70,313,605	$64,693,529	$64,622,471	$82,457,954	+$17,835,483

[a] Bond, etc., includes Calhoun County.
[b] No production in Jefferson County.
[c] Gallatin includes Johnson County.
[d] Hancock, etc., includes Greene County.
[e] No production in Hancock County.
[f] No production in Morgan County.
[g] McLean, etc., includes Marshall County.
[h] McLean, etc., includes Marshall and Will counties in 1916.

INDIANA.

The production of coal in Indiana increased from 17,006,152 net tons, valued at $18,637,476, in 1915 to 20,093,528 tons, valued at $25,506,246, in 1916, a gain of 3,087,376 tons, or 18 per cent, in quantity and of $6,868,770, or 37 per cent, in value. Every important coal-producing county shared in the increase. The supply of labor was in general better than in Illinois. The number of men employed increased from 22,777 in 1915 to 23,965 in 1916, the largest number in any recent year. The average number of days worked was greater than in 1915, 187 against 179, and the average daily and yearly output in tons per man was greater in 1916 than in 1915, 838 tons against 747 tons yearly, and 4.48 tons against 4.17 daily. What has been stated with regard to car supply in Illinois applies in general to Indiana.

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In 1915 little coal from Indiana was sold east of the State. In 1916 shipments were made to points as far east as central New York, and the quantity that was shipped to Ohio and Michigan was limited only by the ability of the operators to get cars on which to load it.

Coal produced in Indiana in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Clay	251,461	27,407	16,583	295,451	$411,709	$1.39	991	110
Daviess	61,429	13,982	3,650	79,061	98,982	1.25	139	182
Dubois and Martin	.....	3,000	.....	3,000	4,212	1.40	11	173
Fountain and Warren	21,000	2,400	400	23,800	27,520	1.16	42	172
Gibson	247,565	15,503	8,109	271,177	283,640	1.05	390	185
Greene	2,207,724	44,623	72,287	2,324,634	2,498,390	1.07	2,720	175
Knox	2,124,061	39,339	48,895	2,212,315	2,222,250	1.00	2,102	218
Owen	82,153	1,465	7,700	91,318	100,029	1.10	63	180
Parke	143,786	7,095	15,767	166,648	294,067	1.76	461	125
Perry	.....	11,075	.....	11,075	14,213	1.28	20	247
Pike	619,269	17,257	9,640	646,166	697,892	1.08	1,015	140
Spencer	576	6,119	.....	6,695	9,609	1.44	18	174
Sullivan	2,495,150	30,625	61,333	2,587,108	2,760,817	1.07	3,931	158
Vanderburg	105,259	115,050	7,022	227,331	310,793	1.37	441	159
Vermilion	2,671,866	6,623	56,057	2,734,546	3,138,355	1.15	3,686	195
Vigo	4,495,377	94,514	98,947	4,688,838	5,125,847	1.09	5,968	193
Warrick	506,343	52,168	18,992	577,473	560,913	.97	779	178
Small mines	.....	59,516	.....	59,516	83,238	1.40	.....	.....
	16,033,089	547,761	425,352	17,006,152	18,637,476	1.10	22,777	179

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Clay	565,797	41,545	22,180	629,522	750	409	1,159	152
Daviess	62,379	12,469	3,689	78,537	100	35	135	186
Dubois, Owen, and Perry	70,688	16,413	7,500	94,601	26	56	82	142
Fountain and Warren	10,000	2,911	1,000	13,911	27	5	32	270
Gibson	315,846	15,071	3,063	333,980	450	37	487	192
Greene	2,311,016	54,612	74,683	2,440,311	2,430	378	2,808	185
Knox	2,637,389	53,410	61,414	2,752,213	2,173	253	2,426	202
Park	267,157	11,024	3,516	281,697	380	67	447	200
Pike	774,924	28,175	12,205	815,304	1,020	97	1,117	182
Spencer	1,610	5,121	15	6,746	18	2	20	189
Sullivan	2,663,094	35,124	65,215	2,763,433	3,089	530	3,619	172
Vanderburg	80,671	238,259	11,205	330,135	390	41	431	234
Vermilion	3,347,987	8,780	63,321	3,420,088	3,253	340	3,593	198
Vigo	5,047,227	124,347	113,968	5,285,542	6,255	514	6,769	185
Warrick	653,783	69,692	20,641	774,116	631	209	840	262
Small mines	.....	73,392	.....	73,392	.....	.....	.....	.....
	18,839,568	790,345	463,615	20,093,528	20,992	2,973	23,965	187

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Value of coal produced in Indiana in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Clay	$805,970	$80,143	$23,348	$909,461	$1.44
Daviess	93,671	21,748	4,408	119,827	1.53
Dubois, Owen, and Perry	98,028	25,297	10,125	133,450	1.41
Fountain and Warren	15,000	6,460	1,500	22,960	1.65
Gibson	423,032	23,360	3,559	449,951	1.35
Greene	2,999,949	82,066	83,398	3,165,413	1.30
Knox	3,072,076	82,552	57,432	3,212,060	1.17
Parke	641,157	19,430	1,758	662,345	2.35
Pike	919,098	38,797	8,831	966,726	1.19
Spencer	2,818	7,456	22	10,296	1.53
Sullivan	3,299,582	48,551	59,900	3,408,033	1.23
Vanderburg	114,396	333,305	15,681	463,382	1.40
Vermilion	4,069,373	13,778	74,249	4,157,400	1.22
Vigo	6,571,615	182,328	118,892	6,872,835	1.30
Warrick	741,457	82,102	17,494	841,053	1.09
Small mines	.....	111,054	.....	111,064	1.51
	23,867,222	1,158,427	490,597	25,506,246	1.27
Average value per ton	1.27	1.47	1.04	1.27	.....

Coal produced in Indiana, 1912–1916, in net tons.

County.	1912	1913	1914	1915	1916	Increase or decrease, 1916.
Clay	700,323	564,957	454,009	295,451	629,522	+ 334,071
Daviess	105,079	84,030	91,608	79,061	78,537	− 524
Dubois	[a] 16,500	[a] 7,948	[a] 5,400	[a] 3,000	[a] 94,601	− 10,792
Fountain and Warren	5,066	64,902	40,764	23,800	13,911	− 9,889
Gibson	228,557	227,100	280,636	271,177	333,980	+ 62,803
Greene	2,636,509	2,780,708	2,230,085	2,324,634	2,440,311	+ 115,677
Knox	1,212,506	1,760,748	1,619,083	2,212,315	2,752,213	+ 539,898
Owen	30,707	127,283	111,355	[a] 91,318	(a)	.....
Parke	523,150	507,508	331,845	166,648	281,697	+ 115,049
Perry	15,904	14,910	13,800	[a] 11,075	(a)	.....
Pike	559,337	583,637	578,693	646,166	815,304	+ 169,138
Spencer	10,306	8,479	8,510	6,695	6,746	+ 51
Sullivan	3,091,368	3,084,419	2,999,148	2,587,108	2,763,433	+ 176,325
Vanderburg	302,074	280,522	288,191	227,331	330,135	+ 102,804
Vermilion	1,547,126	2,085,311	2,135,836	2,734,546	3,420,088	+ 685,542
Vigo	3,564,046	4,237,274	4,767,828	4,688,838	5,285,542	+ 596,704
Warrick	691,475	685,020	624,770	577,473	774,116	+ 196,643
Small mines	45,595	60,915	59,571	59,516	73,392	+ 13,876
Total	15,285,718	17,165,671	16,641,132	17,006,152	20,093,528	+ 3,087,376
Total value	$17,480,546	$19,001,881	$18,290,928	$18,637,476	$25,506,246	+$6,868,770

[a] Dubois includes Martin in 1912–1915, and Owen and Perry in 1915–1916.

IOWA.

The production of coal in Iowa in 1916 was 7,260,800 net tons, valued at $13,530,383, a decrease, compared with 1915, of 353,343 tons, or 5 per cent, in quantity and of $47,225, or 0.3 per cent, in value. The production in 1916 was the lowest since 1905, except in the year 1908. The decrease in the State was due to the falling off in production in Monroe County, where the output in 1916 was 1,719,844 tons, a decrease of 384,735 tons, compared with 1915. Small decreases were recorded for Jasper, Mahaska, and Polk counties. The other important producing counties had increased output.

There was a decrease in the number of men employed from 15,549 in 1915 to 14,443 in 1916, and in the days worked from 220 in 1915 to 202 in 1916.

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The increase in the average daily output per man from 2.23 in 1915 to 2.49 in 1916 is attributed in large part to the greater use of mining machines. In 1916 there were 56 machines in use against 45 in 1915, and the quantity of machine-mined coal increased from 5.5 to 8.8 per cent of the total output.

Coal produced in Iowa in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Adams	120	8,120	100	8,340	$21,300	$2.55	45	174
Appanoose	1,147,423	57,508	20,169	1,225,100	2,376,497	1.94	4,139	245
Boone	109,731	41,384	5,145	156,260	329,676	2.11	447	195
Dallas	449,262	11,219	10,400	470,881	905,355	1.92	863	214
Greene, Lucas, Warren, and Wayne	574,917	16,717	6,150	597,784	1,071,692	1.79	922	232
Guthrie	.....	3,968	.....	3,968	10,887	2.74	27	157
Jasper	252,096	15,961	110	268,167	555,030	2.07	514	223
Jefferson, Keokuk, and Van Buren	.....	6,710	.....	6,710	16,286	2.43	25	183
Mahaska	229,408	13,765	2,618	245,786	395,629	1.61	432	192
Marion	322,242	28,116	9,797	360,155	552,968	1.54	782	218
Monroe	2,058,876	40,841	57,632	2,157,349	3,418,329	1.58	3,704	206
Page and Taylor	4,000	4,617	.....	8,617	21,543	2.50	49	182
Polk	1,509,531	208,685	31,068	1,744,304	3,255,677	1.87	2,932	223
Wapello	293,717	15,626	4,650	313,993	549,467	1.75	589	179
Webster	12,380	6,225	300	18,905	41,025	2.17	79	147
Small mines	.....	27,824	.....	27,824	56,247	2.02	.....	.....
	6,963,698	502,286	148,159	7,614,143	13,577,608	1.78	15,549	220

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Adams	240	10,663	800	11,703	43	7	50	204
Appanoose	1,140,041	68,184	18,902	1,227,127	3,366	353	3,719	182
Boone	116,775	48,607	5,200	170,582	362	51	413	180
Dallas	445,039	26,432	2,500	473,971	702	68	770	232
Greene, Lucas, Warren, and Wayne	706,837	22,407	13,060	742,304	1,057	113	1,170	.....
Guthrie and Webster	8,500	10,000	300	18,800	55	8	63	.....
Jasper	220,864	11,961	.....	232,825	391	45	436	214
Jefferson, Keokuk, and Van Buren	475	6,906	.....	7,381	26	8	34	.....
Mahaska	145,143	12,990	1,262	159,395	255	47	302	201
Marion	320,087	25,169	16,544	361,800	612	81	693	202
Monroe	1,689,158	36,160	47,296	1,772,614	3,147	385	3,532	183
Page and Taylor	5,360	4,801	.....	10,161	38	5	43	.....
Polk	1,431,595	249,645	38,604	1,719,844	2,420	247	2,667	238
Wapello	291,656	21,831	2,845	316,332	486	65	551	210
Small mines	.....	35,961	.....	35,961	.....	.....	.....	.....
	6,521,770	591,717	147,313	7,260,800	12,960	1,483	14,443	202

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Value of coal produced in Iowa in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Adams	$670	$29,717	$1,400	$31,787	$2.72
Appanoose	2,256,668	146,548	12,817	2,416,033	1.97
Boone	286,777	119,085	5,200	411,062	2.41
Dallas	833,985	53,251	2,775	890,011	1.88
Greene, Lucas, Warren, and Wayne	1,267,917	60,508	14,941	1,333,366	1.80
Guthrie and Webster	16,575	23,866	438	40,879	2.17
Jasper	430,685	34,764	.....	465,449	2.00
Jefferson, Keokuk, and Van Buren	950	15,875	.....	16,825	2.28
Mahaska	275,708	24,124	862	300,694	1.89
Marion	517,044	49,229	17,094	583,367	1.61
Monroe	2,828,288	73,985	41,097	2,943,370	1.66
Page and Taylor	12,328	13,553	.....	25,881	2.55
Polk	2,791,444	545,386	56,551	3,393,381	1.97
Wapello	553,426	40,579	3,632	597,637	1.89
Small mines	.....	80,641	.....	80,641	2.24
Average value per ton	12,062,465 1.85	1,311,111 2.22	156,807 1.06	13,530,383 1.86	1.86

Coal produced in Iowa in 1912–1916, in net tons.

County.	1912	1913	1914	1915	1916	Increase or decrease, 1916.
Adams	9,868	6,971	6,660	8,340	11,703	+ 3,363
Appanoose	1,252,666	1,207,387	1,272,276	1,225,100	1,227,127	+ 2,027
Boone	212,168	256,212	181,952	156,260	170,582	+ 14,322
Dallas	436,206	574,186	466,697	470,881	473,971	+ 3,090
Greene, Lucas, and Warren	28,644	40,934	302,132	[a] 597,784	[a] 742,304	+[a] 144,520
Guthrie	5,870	4,492	3,925	3,968	[b] 18,800	− [b] 4,073
Jasper	271,301	267,567	241,991	268,167	232,825	− 35,342
Jefferson, Keokuk, and Van Buren	27,692	21,785	13,149	6,710	7,381	+ 671
Mahaska	578,843	355,737	272,868	245,786	159,395	− 86,391
Marion	182,068	298,552	311,183	360,155	361,800	+ 1,645
Monroe	2,393,412	2,571,277	2,273,066	2,157,349	1,772,614	− 384,735
Page and Taylor	10,170	7,473	9,902	8,617	10,161	+ 1,544
Polk	1,486,053	1,601,015	1,706,779	1,744,304	1,719,844	− 24,460
Wapello	206,102	153,705	237,176	313,993	316,332	+ 2,339
Wayne	99,168	85,775	76,524	(a)	(a)	(a)
Webster	48,074	45,676	33,692	[b] 18,905	(b)	(b)
Small mines	[c] 41,224	27,192	41,050	27,824	35,961	+ 8,137
Total	7,289,529	7,525,936	7,451,022	7,614,143	7,260,800	− 353,343
Total value	$13,152,088	$13,496,710	$13,364,070	$13,577,608	$13,530,383	− $47,225

[a] Greene, etc., includes Wayne County.
[b] Guthrie includes Webster County in 1916.
[c] Includes Scott County.

KANSAS.

The production of coal in Kansas in 1916 was 6,881,455 net tons, only 56,981 tons, or less than 1 per cent, greater than in 1915. The total value of the product at the mines, however, increased $892,093, or 9 per cent. The increase in Crawford County, 210,000 tons, was largely offset by the decrease of 178,000 tons in Cherokee County.

The decrease in the number of men employed, from 13,260 in 1915 to 12,132 in 1916, was overcome by the increase in the number of days worked, from 184 to 204.

The mining of coal in open pits by means of steam shovels has become an important feature in the coal fields in Crawford and Cherokee counties. This method of mining has effected large economies in

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the cost of operation as compared with underground systems and has given these fields, in which the coal beds are thin and expensive to mine, a new lease on life. There were 24 shovels at work in Kansas at the end of 1916, and more than 858,000 tons of coal (12.5 per cent of the output of the State) were taken from the steam-shovel pits.

Coal produced in Kansas in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Cherokee	1,665,555	8,429	33,472	1,707,456	$2,786,419	$1.63	2,834	187
Crawford	4,672,842	56,274	114,116	4,843,232	7,943,164	1.64	9,094	182
Leavenworth	106,206	10,523	36,326	153,055	320,898	2.16	690	238
Linn	2,541	8,000	.....	10,541	20,276	1.92	30	202
Osage	88,728	11,894	157	100,779	258,186	2.56	612	151
Small mines	.....	9,411	.....	9,411	22,687	2.41	.....	.....
	6,535,872	104,531	184,071	6,824,474	11,360,630	1.66	13,260	184

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees. (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Cherokee	1,477,636	10,881	40,936	1,529,453	1,641	523	2,164	211
Crawford	4,874,331	65,632	113,276	5,053,239	7,658	1,191	8,849	198
Leavenworth	110,338	34,325	4,959	149,622	476	59	535	276
Linn	4,067	4,219	.....	8,306	27	3	30	231
Osage	110,672	14,382	167	125,221	523	31	554	194
Small mines	.....	15,614	.....	15,614	.....	.....	.....	.....
	6,577,064	145,053	159,338	6,881,455	10,325	1,807	12,132	204

Value of coal produced in Kansas in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Cherokee	$2,750,017	$16,152	$59,716	$2,825,885	$1.85
Crawford	8,403,436	117,318	142,944	8,663,698	1.71
Leavenworth	273,942	83,906	9,799	367,647	2.46
Linn	8,174	8,960	.....	17,134	2.06
Osage	299,235	41,104	355	340,694	2.72
Small mines	.....	37,665	.....	37,665	2.41
	11,734,804	305,105	212,814	12,252,723	1.78
Average value per ton	1.78	2.10	1.34	1.78	.....

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Coal produced in Kansas, 1912–1916, in net tons.

County.	1912	1913	1914	1915	1916	Increase or decrease, 1916.
Cherokee	2,332,944	2,289,019	1,882,810	1,707,456	1,529,453	− 178,003
Crawford	4,255,415	4,614,257	4,752,114	4,843,233	5,053,239	+ 210,007
Leavenworth	204,523	161,209	110,791	153,055	149,622	− 3,433
Linn	33,588	25,212	10,480	10,541	8,306	− 2,235
Osage	135,796	115,810	88,371	100,779	125,221	+ 24,442
Small mines	[a] 23,916	[b] 26,703	[b] 16,422	9,411	15,614	+ 6,203
Total	6,986,182	7,202,210	6,860,988	6,824,474	6,881,455	+ 56,981
Total value	$11,324,130	$12,036,292	$11,238,253	$11,360,630	$12,252,723	+$892,093

[a] Includes Franklin and Neosho counties. [b] Includes Franklin County.

KENTUCKY.

The production of coal in Kentucky in 1916 was 25,393,997 net tons, valued at $30,193,047, an increase compared with 1915 of 4,032,323 tons, or 19 per cent, in quantity and of $8,699,039, or 40.5 per cent, in value. The production in western Kentucky was 7,786,556 tons, an increase of 3 per cent over 1915. The output of the mines in Hopkins and Webster counties was largely increased, but in other parts of western Kentucky there was a general decrease or but slight increases in output. The demand for coal from western Kentucky was about normal during the first nine months of the year. In October railroad consumption increased and a car shortage was first felt. The increased demand in the last quarter offset the decreased shipments to the lower Mississippi Valley that followed a lowering of the rates on competitive coal from Alabama earlier in the year.

The increase in production in eastern Kentucky, 3,805,705 tons, was largely in the by-product and gas coals, but was shared by the domestic and steam coals. The largest increases in production in the eastern part of the State were in Floyd, Harlan, Letcher, Perry, and Pike counties. The only important producing county that recorded a decrease was Bell. There has been a notable extension of markets for coal from eastern Kentucky in the last two years in the territory north of Ohio River and in the States to the northwest, and the demand from Michigan in particular was strong in the last half of 1916. The business was affected by the shortage of cars and the railroad embargoes in the last quarter of the year, and many of the companies were a month or more behind on their orders and were unable to profit to any extent by the higher market prices in effect from October to the end of the year. In the Cincinnati Southern district, in McCreary County, car supply and labor supply were about equal. In Knox County many of the mines were short of labor and all were affected by car shortage in the last quarter. Both car and labor shortage were reported from Floyd and Johnson counties, at a number of the mines on Big Sandy River, and at mines on the headwaters of Kentucky River, in Letcher County.

Although the supply of labor was reported as inadequate to meet the demand, the number of men employed in the coal mines of both eastern and western Kentucky in 1916 was greater than in 1915, and the total for the State in 1916, 31,222 men, was the greatest in the history of the industry in this State. The working time in the

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eastern district increased from 205 days in 1915 to 231 days in 1916, and increased in the western district from 154 to 162 days. Letcher County, in the east, with 274 days worked, and Daviess County in the west, with 240 days worked, had the highest percentage of working time.

Coal produced in Kentucky in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Eastern district:									
Bell	2,210,498	47,769	48,564	.....	2,306,831	$2,414,790	$1.05	3,551	209
Boyd	73,211	2,871	1,918	.....	78,000	65,872	.84	164	191
Breathitt, Greenup, Knott, Lawrence, and Lee	67,401	6,218	973	.....	74,592	77,541	1.04	114	207
Carter	65,152	3,649	14,612	.....	83,413	89,669	1.08	161	179
Floyd	510,059	26,164	8,851	.....	545,074	566,174	1.04	711	178
Harlan	1,390,346	12,312	15,677	308,463	1,726,798	1,827,144	1.06	1,496	226
Jackson and Pulaski	1,837	3,581	.....	.....	5,418	6,895	1.27	17	147
Johnson	928,645	17,897	28,922	.....	975,464	1,267,332	1.30	1,282	221
Knox	746,796	5,043	15,874	.....	767,713	815,986	1.06	1,480	195
Laurel	84,302	55	779	.....	85,136	84,896	.99	229	143
Letcher	2,204,129	12,234	12,971	.....	2,229,334	2,656,628	1.19	2,159	226
McCreary	566,767	1,781	987	.....	569,535	642,244	1.13	970	173
Morgan	51,410	5,762	1,643	.....	58,815	128,450	2.18	202	254
Perry	532,998	2,261	12,703	.....	547,962	615,690	1.12	724	242
Pike	2,648,211	37,043	50,913	94,072	2,830,239	2,689,825	.95	2,928	211
Whitley	776,450	7,684	21,312	.....	805,446	1,068,984	1.33	1,782	162
	12,858,212	192,324	236,699	402,535	13,689,770	15,018,120	1.10	17,970	205
Western district:									
Christian and McLean	92,356	350	550	.....	93,256	85,503	.92	184	176
Daviess	6,000	35,320	1,458	.....	42,778	41,157	.96	67	232
Hancock	1,000	3,000	.....	.....	4,000	5,425	1.36	12	190
Henderson	103,787	52,896	10,021	.....	166,704	184,834	1.11	261	195
Hopkins	2,129,808	49,568	97,197	55,570	2,332,143	1,843,827	.79	2,737	149
Muhlenberg	2,159,213	22,559	50,273	.....	2,232,045	1,844,506	.83	3,451	143
Ohio	463,168	33,906	22,746	.....	519,820	417,373	.80	1,108	111
Union	653,818	47,679	40,613	.....	742,110	708,440	.96	756	213
Webster	1,354,030	19,214	35,756	.....	1,409,000	1,172,929	.83	1,414	176
	6,963,180	264,492	258,614	55,570	7,541,856	6,303,994	.84	9,990	154
Small mines	.....	130,048	.....	.....	130,048	171,894	1.32	.....	.....
Grand total	19,821,392	586,864	495,313	458,105	21,361,674	21,494,008	1.01	27,960	186

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Coal produced in Kentucky in 1915 and 1916—Continued.

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Eastern district:									
Bell	2,182,454	27,859	34,229	.....	2,244,542	3,308	621	3,929	208
Boyd	74,179	9,229	2,173	.....	85,581	139	49	188	232
Breathitt, Greenup, Knott, Lawrence, and Lee	32,912	3,700	600	.....	37,212	63	20	83	144
Carter	119,258	3,983	336	.....	123,577	145	31	176	288
Floyd	851,158	8,149	14,146	.....	873,453	772	157	929	197
Harlan	1,879,589	18,155	15,673	300,811	2,214,228	1,651	435	2,086	219
Jackson and Pulaski	4,985	5,023	156	.....	10,164	16	7	23	200
Johnson	932,808	12,210	30,468	.....	975,486	974	255	1,229	240
Knox	775,426	13,437	14,661	.....	803,524	1,110	261	1,371	214
Laurel	86,803	120	715	.....	87,638	200	18	218	165
Letcher	3,627,815	16,555	27,066	.....	3,671,436	3,002	304	3,306	274
McCreary	654,340	9,950	1,000	.....	665,290	898	93	991	256
Morgan	47,573	1,092	62	.....	48,727	149	36	185	258
Perry	973,760	4,753	13,749	.....	992,262	846	261	1,107	224
Pike	3,285,961	128,891	52,850	289,225	3,756,927	2,705	608	3,313	252
Whitley	869,198	13,650	22,670	.....	905,428	1,519	269	1,788	197
	16,398,129	276,756	230,554	590,036	17,495,475	17,497	3,425	20,922	231
Western district:									
Christian	103,875	1,100	3,000	.....	107,975	170	24	194	235
Daviess	.....	59,335	520	.....	59,855	63	12	75	240
Henderson	111,334	65,771	8,643	.....	185,748	277	45	322	192
Hopkins	2,356,617	104,260	99,117	62,531	2,622,525	2,260	415	2,675	179
McLean	54,160	4,020	200	.....	58,380	63	11	74	190
Muhlenburg	1,962,127	28,814	45,878	.....	2,036,819	3,219	359	3,578	140
Ohio	428,339	33,966	22,535	.....	484,940	1,073	105	1,178	112
Union	542,538	74,878	42,660	.....	660,076	697	141	838	168
Webster	1,515,302	23,402	31,534	.....	1,570,238	1,182	184	1,366	209
	7,074,292	395,546	254,187	62,531	7,786,556	9,004	1,296	10,300	162
Small mines[a]	1,000	110,966	.....	.....	111,966	.....	.....	.....	.....
Grand total	23,473,421	783,268	484,741	652,567	25,393,997	26,501	4,721	31,222	208

[a] Includes Hancock County.

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Value of coal produced in Kentucky in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Eastern district:						
Bell	$2,907,611	$39,442	$34,253	.....	$2,981,306	$1.33
Boyd	88,282	10,792	2,850	.....	101,924	1.19
Breathitt, Greenup, Knott, Lawrence, and Lee	46,590	4,875	875	.....	52,340	1.41
Carter	171,229	5,175	361	.....	176,765	1.43
Floyd	1,148,198	9,763	13,610	.....	1,171,571	1.34
Harlan	2,495,767	31,995	18,991	$300,814	2,847,567	1.29
Jackson and Pulaski	7,929	5,525	140	.....	13,594	1.34
Johnson	1,471,493	17,409	40,077	.....	1,528,979	1.57
Knox	984,408	17,053	14,080	.....	1,015,541	1.26
Laurel	93,122	130	745	.....	93,997	1.07
Letcher	4,651,497	22,927	33,604	.....	4,708,028	1.28
McCreary	660,470	13,978	2,000	.....	676,448	1.02
Morgan	100,393	2,585	91	.....	103,069	2.12
Perry	1,358,730	5,819	16,247	.....	1,380,796	1.39
Pike	3,573,653	126,934	47,284	267,223	4,015,094	1.07
Whitley	1,349,174	25,624	29,184	.....	1,403,982	1.55
	21,108,546	340,026	254,392	568,037	22,271,001	1.27
Average value per ton	1.29	1.23	1.10	.96	1.27	.....
Western district:						
Christian	137,432	1,165	1,500	.....	140,097	1.30
Daviess	.....	76,638	568	.....	77,206	1.29
Henderson	119,889	96,026	8,909	.....	224,824	1.21
Hopkins	2,228,838	89,999	88,574	58,779	2,466,190	.94
McLean	70,584	4,040	200	.....	74,824	1.28
Muhlenberg	2,063,637	33,665	36,172	.....	2,153,474	1.06
Ohio	392,916	41,925	7,303	.....	432,144	.89
Union	566,434	98,925	33,262	.....	698,621	1.06
Webster	1,435,125	23,298	28,932	.....	1,487,355	.95
	7,024,855	465,681	205,420	58,779	7,754,735	1.00
Average value per ton	.99	1.18	.81	.94	1.00	.....
Small mines[a]	1,750	165,561	.....	.....	167,311	1.49
Grand total	28,135,151	971,268	459,812	626,816	30,193,047	1.19
Average value per ton	1.20	1.24	.95	.96	1.19	.....

[a] Includes Hancock County.

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Coal produced in Kentucky, 1913–1916, in net tons.

County.	1913	1914	1915	1916	Increase or decrease, 1916.
Eastern district:					
Bell	2,488,538	2,579,011	2,306,831	2,244,542	− 62,289
Boyd	131,208	92,882	78,000	85,581	+ 7,581
Breathitt, Greenup, Lawrence, and Lee	105,396	[a] [b] 113,242	[b] 74,592	[b] 37,212	− 37,380
Carter	110,595	84,475	83,413	123,577	+ 40,164
Floyd	445,949	524,923	545,074	873,453	+ 328,379
Harlan	750,267	1,264,066	1,726,798	2,214,228	+ 487,430
Johnson	861,189	935,630	975,464	975,486	+ 22
Knox	961,492	904,684	767,713	803,524	+ 35,811
Laurel	196,569	101,205	85,136	87,638	+ 2,502
Letcher	[c]	1,427,626	2,229,334	3,671,436	+1,442,102
McCreary	625,101	586,541	569,535	665,290	+ 95,755
Morgan	90,346	76,028	58,315	48,727	− 10,088
Perry	24,953	221,012	547,962	992,262	+ 444,300
Pike	2,124,041	2,653,315	2,830,239	3,756,927	+ 926,688
Whitley	1,015,370	854,019	805,446	905,428	+ 99,982
Other counties [c]	1,107,833	3,100	5,418	[c] 10,164	+ 4,746
	11,038,847	12,421,759	13,689,770	17,496,475	+3,805,705
Western district:					
Christian	69,525	[d] 83,905	[d] 93,256	[d] 107,975	+ [d] 73,099
Daviess	48,543	47,538	42,778	59,855	+ 17,077
Hancock	6,280	7,000	4,000	[e]	[e]
Henderson	220,582	161,066	166,704	185,748	+ 19,044
Hopkins	2,534,821	2,551,720	2,332,143	2,622,525	+ 290,382
McLean	83,329	[d]	[d]	58,380	[d]
Muhlenberg	2,633,271	2,265,153	2,232,045	2,036,819	− 195,226
Ohio	775,545	660,273	519,820	484,940	− 34,880
Union	690,968	585,743	742,110	660,076	− 82,034
Webster	1,394,663	1,475,790	1,409,000	1,570,238	+ 161,238
	8,457,527	7,838,188	7,541,856	7,786,556	+ 248,700
Small mines	120,226	122,816	130,048	[e] 111,966	− 22,082
Grand total	19,616,600	20,382,763	21,361,674	25,393,997	+4,032,323
Total value	$20,516,749	$20,852,463	$21,494,008	$30,193,047	+$8,699,039

[a] No production in Greenup County.
[b] Includes Knott County.
[c] Other counties include Clay, Letcher, and Pulaski in 1913; Clay, Pulaski, and Rockcastle in 1914; Jackson and Pulaski in 1915 and 1916.
[d] Christian and McLean counties combined.
[e] Hancock County included in small mines.

MARYLAND.

The production of coal in Maryland in 1916 was 4,460,046 net tons, valued at $6,947,623, an increase of 279,569 tons, or nearly 7 per cent in quantity and of $1,616,778, or 30 per cent, in value.

There was little change in the number of men employed, 5,633 in 1916 against 5,664 in 1915, or in the average daily output per man. The increase was attained by working more days, the increase in this regard having been from 242 days in 1915 to 256 in 1916.

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Coal produced in Maryland in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons.	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Allegany	3,308,100	22,234	58,031	3,388,365	$4,599,992	$1.36	4,728	248
Garrett	768,881	7,538	6,557	782,976	720,214	.92	936	212
Small mines	.....	9,136	.....	9,136	10,669	1.17	.....	.....
	4,076,981	38,908	64,588	4,180,477	5,330,845	1.28	5,664	242

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total. quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Allegany	3,342,332	55,067	57,055	3,454,454	3,900	700	4,600	260
Garrett	978,388	8,143	8,158	994,694	819	214	1,033	234
Small mines	.....	10,898	.....	10,898	.....	.....	.....	.....
	4,320,720	74,113	65,213	4,460,046	4,719	914	5,633	256

Value of coal produced in Maryland in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Allegheny	$5,511,695	$89,632	$93,747	$5,695,074	$1.65
Garrett	1,218,373	9,289	11,014	1,238,676	1.25
Small mines	.....	13,873	.....	13,873	1.27
	6,730,068	112,794	104,761	6,947,623	1.56
Average value per ton	1.56	1.52	1.61	1.56	.....

Coal produced in Maryland, 1913–1916, in net tons.

County.	1913	1914	1915	1916	Increase, decrease, 1916.
Allegheny	4,038,261	3,449,365	3,388,365	3,454,454	+ 66,089
Garrett	731,089	671,621	782,976	994,694	+ 211,718
Small mines	10,489	12,561	9,136	10,898	+ 1,762
Total	4,779,839	4,133,547	4,180,477	4,460,046	+ 279,569
Total value	$5,927,046	$5,234,796	$5,330,845	$6,947,623	+$1,616,778

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MICHIGAN.

The production of coal in Michigan increased 2 per cent, from 1,156,138 net tons in 1915 to 1,180,360 tons in 1916.

The car and labor supply was adequate throughout the year and the increased output was obtained from the same mines that were in operation in 1915, which worked an average of 216 days in 1916 against 198 days in 1915. The quantity of bituminous coal, exclusive of railroad fuel, consumed in Michigan is in normal times from 10 to 13 times that supplied by the local mines, and any restriction of the supply of coal from other States creates an extra demand for the product of the Michigan mines. Such a condition arose in the second half of 1916, and the Michigan coal operators were able to sell at good prices all that they could produce.

The total value of the output of coal in Michigan in 1916 was $2,653,182.

Coal produced in Michigan in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Bay	530,548	2,541	18,683	551,772	$1,081,452	$1.96	1,206	194
Ingham and Tuscola	54,670	2,530	7,450	64,650	162,569	2.51	175	193
Saginaw	492,727	36,723	9,586	539,036	1,126,717	2.09	1,188	202
Small mines	.....	680	.....	680	2,059	3.03	.....	.....
	1,077,945	42,474	35,719	1,156,138	2,372,797	2.05	2,569	198

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Bay	540,114	2,104	7,089	549,307	972	187	1,159	210
Ingham and Tuscola	55,769	5,210	9,200	70,179	164	21	185	230
Saginaw	501,224	44,141	15,194	560,559	988	203	1,191	219
Small mines	.....	315	.....	315	.....	.....	.....	.....
	1,097,107	51,770	31,483	1,180,360	2,124	411	2,535	216

Value of coal produced in Michigan in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Bay	$1,178,380	$6,727	$12,596	$1,197,703	$2.18
Ingham and Tuscola	127,711	14,358	15,640	157,709	2.25
Saginaw	1,136,011	132,037	28,727	1,296,775	2.31
Small mines	.....	995	.....	995	3.16
	2,442,102	154,117	56,963	2,653,182	2.25
Average value per ton	2.23	2.96	1.81	2.25	.....

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Coal produced in Michigan, 1912–1916, in net tons.

County.	1912	1913	1914	1915	1916	Increase or decrease, 1916.
Bay	630,931	591,718	617,415	551,772	549,307	— 2,465
Saginaw	504,612	596,193	584,648	539,036	560,559	+ 21,523
Tuscola	[c]70,476	[b]42,715	[c]80,866	[d]64,650	[c]70,179	+ 5,529
Small mines	211	1,160	101	680	315	— 365
Total	1,206,230	1,231,786	1,283,030	1,156,138	1,180,360	+ 24,222
Total value	$2,399,451	$2,455,227	$2,559,786	$2,372,797	$2,653,182	+ $280,385

[a] Includes Clinton and Ingham counties.
[b] Includes Clinton, Ingham, and Shiawassee counties.
[c] Includes Genesee and Ingham counties.
[d] Includes Ingham County.
[e] Included with Tuscola County.

MISSOURI.

A new record for the production of coal in Missouri was attained in 1916 with an output of 4,742,146 tons, an increase compared with 1915 of 930,553 tons, or more than 24 per cent, and compared with 1912, the year of previous high record, of 9 per cent. The value at the mines of the coal produced in Missouri in 1916 was $9,044,505, an increase of $2,448,587, or 37 per cent. Except Henry and Randolph counties, every important producing county had an increased output. There was in general an adequate supply of labor, the number of men increasing from 9,173 in 1915 to 9,654 in 1916. The average number of days worked increased from 186 to 207.

Coal produced in Missouri in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Adair	261,052	11,734	7,401	280,187	$443,209	$1.58	894	140
Audrain	5,780	7,745	278	13,803	32,184	2.33	51	228
Barton	635,952	4,111	17,006	657,069	1,085,391	1.65	880	183
Bates	61,912	6,916	2,484	71,312	111,756	1.57	165	140
Boone	.....	17,450	.....	17,450	38,141	2.19	46	186
Callaway	32,770	29,494	1,872	64,136	128,089	2.00	129	261
Caldwell, Clay, Dade, Johnson, and Platte	60,039	27,534	1,391	88,964	194,141	2.18	347	206
Cooper and Moniteau	1,500	1,850	.....	3,350	9,500	2.84	9	200
Grundy, Harrison, and Sullivan	79,402	16,061	8,418	103,881	175,030	1.69	168	178
Henry	157,233	23,279	2,799	183,311	305,781	1.67	454	193
Lafayette	710,629	64,986	23,682	799,297	1,492,049	1.87	2,383	200
Linn	76,101	19,352	1,789	97,242	228,172	2.35	341	213
Macon	638,592	19,080	8,563	666,245	1,039,453	1.56	1,393	180
Randolph	350,486	24,284	4,492	379,262	602,390	1.59	830	236
Ray	177,061	25,469	2,654	205,184	389,028	1.90	944	132
Vernon	72,036	1,179	1,262	75,377	117,442	1.56	117	223
Other counties [a]	14,082	1,021	.....	15,103	28,288	1.87	42	254
Small mines	.....	90,420	.....	90,420	175,844	1.94	.....	.....
	3,335,527	391,975	84,091	3,811,593	6,595,918	1.73	9,173	186

[a] Livingston, Putnam, and Ralls.

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Coal production in Missouri in 1915 and 1916—Continued.

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Adair	419,016	11,816	5,581	436,413	917	59	976	185
Audrain	161	6,824	.....	6,985	30	3	33	217
Barton	898,911	13,391	23,322	935,624	163	834	997	189
Bates	66,799	14,600	2,135	83,534	103	102	205	135
Boone	650	17,806	100	18,556	58	10	68	178
Callaway	35,210	24,447	2,157	61,814	99	46	145	250
Clay, Dade, Johnson, and Platte	94,749	6,648	1,033	102,430	246	44	290	222
Grundy, Harrison, and Sullivan	64,112	17,683	7,716	89,511	163	21	184	200
Henry	130,540	39,271	2,122	171,933	338	78	416	203
Lafayette	838,614	49,116	25,386	907,116	2,215	218	2,433	214
Linn	85,985	21,969	384	108,338	291	36	327	242
Macon	765,538	21,797	8,296	795,631	1,233	150	1,383	211
Putnam	5,631	2,728	160	8,519	58	10	68	83
Randolph	347,602	17,779	3,182	368,563	787	46	833	219
Ray	374,033	33,652	5,290	412,975	1,082	64	1,146	213
Vernon	77,872	3,972	.....	81,844	55	51	106	244
Other counties [a]	13,991	1,522	.....	15,513	39	5	44	246
Small mines	.....	136,847	.....	136,847	.....	.....	.....	.....
	4,219,414	435,868	86,864	4,742,146	7,877	1,777	9,654	207

[a] Cooper, Livingston, Montgomery, and Ralls.

Value of coal produced in Missouri in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Adair	$693,396	$32,255	$5,240	$730,891	$1.67
Audrain	320	15,404	.....	15,724	2.25
Barton	1,726,775	19,999	37,438	1,784,212	1.91
Bates	129,210	30,840	3,235	163,285	1.95
Boone	1,300	48,579	200	50,079	2.70
Callaway	66,977	67,976	3,801	138,754	2.24
Clay, Dade, Johnson, and Platte	224,870	14,234	1,588	240,692	2.35
Grundy, Harrison, and Sullivan	108,545	42,206	8,016	158,767	1.77
Henry	234,235	84,083	3,697	322,015	1.87
Lafayette	1,707,017	112,976	41,129	1,861,122	2.05
Linn	202,124	63,094	768	265,986	2.46
Macon	1,243,211	48,755	10,443	1,302,409	1.64
Putnam	12,274	5,545	171	17,990	2.11
Randolph	661,189	31,989	1,815	694,993	1.89
Ray	748,377	77,827	10,417	836,621	2.03
Vernon	143,334	4,254	.....	147,588	1.80
Other counties [a]	26,186	3,305	.....	29,491	1.90
Small mines	.....	283,886	.....	283,886	2.07
	7,929,340	987,207	127,958	9,044,505	1.91
Average value per ton	1.88	2.26	1.47	1.91	.....

[a] Cooper, Livingston, Montgomery, and Ralls.

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Coal produced in Missouri, 1913–1916, in net tons.

County.	1913	1914	1915	1916	Increase or decrease, 1916.
Adair	439,991	256,397	280,187	436,413	+ 156,226
Audrain	10,006	10,360	13,803	6,985	− 6,818
Barton	496,328	505,282	657,069	935,624	+ 278,555
Bates	168,469	145,031	71,312	83,534	+ 12,222
Boone	15,791	12,514	17,450	18,556	+ 1,106
Caldwell, Clay, Dade, Johnson, and Platte	101,158	110,559	88,964	[a] 102,430	+ 13,466
Callaway	32,889	39,555	64,136	61,814	− 2,322
Cole, Cooper, and Moniteau	3,931	[b] 3,032	[b g] 3,350	(b d g)	(b d g)
Grundy, Harrison, Schuyler, and Sullivan	192,932	114,949	[c] 103,881	[c] 89,511	− 14,370
Henry	261,196	224,894	183,311	171,933	− 11,378
Howard, Montgomery, and Ralls	26,287	[e] 23,900	(f g)	(g h)	(g h)
Lafayette	729,606	703,029	799,297	907,116	+ 107,819
Linn	117,625	108,626	97,242	108,338	+ 11,096
Macon	778,264	765,365	666,245	795,631	+ 129,386
Putnam	21,835	10,367	(g)	8,519	+ 8,519
Randolph	481,882	424,245	379,262	368,563	− 10,699
Ray	343,285	324,080	205,184	412,975	+ 207,791
Vernon	10,073	43,165	75,377	81,844	+ 6,467
Other counties	.....	.....	[g] 15,103	15,513	− 2,940
Small mines	86,977	110,630	90,420	136,847	+ 46,427
Total	4,318,125	3,935,980	3,811,593	4,742,146	+ 930,553
Total value	$7,468,308	$6,802,325	$6,596,918	$9,044,505	+$2,448,587

[a] No production in Caldwell County.
[b] No production in Cole County.
[c] No production in Schuyler County.
[d] No production in Moniteau County.
[e] No production in Montgomery County.
[f] No production in Howard and Montgomery counties.
[g] Other counties include Livingston and Vernon in 1912; Livingston, Putnam, and Ralls in 1915; and Cooper, Livingston, Montgomery, and Ralls in 1916.
[h] No production in Howard County.

MONTANA.

The production of coal in Montana increased 842,772 net tons, or 30 per cent, from 2,789,755 tons in 1915 to 3,632,527 tons in 1916. The most notable increase was in Fergus County (Lewiston field), from 68,362 tons in 1915 to 232,681 tons in 1916.

The labor supply was adequate throughout the year, although it is reported that the mines on the Northern Pacific Railway could have used more men if they had been available. The number of men employed increased from 3,158 in 1915 to 3,781 in 1916. The car supply was ample until October and was not materially curtailed at any time. The average number of days worked increased from 201 in 1915 to 244 in 1916. The consumption of coal by the railroads was above normal, notwithstanding their increased use of electricity.

Coal produced in Montana in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked
Carbon	1,068,226	31,575	72,920	1,172,721	$2,137,043	$1.82	1,503	187
Cascade	588,424	25,224	6,097	619,745	900,764	1.45	711	195
Fergus	57,686	3,031	7,645	68,362	96,859	1.42	97	226
Hill	2,521	11,471	125	14,117	34,132	2.42	24	251
Musselshell	841,192	10,083	35,746	887,021	1,297,319	1.46	792	231
Sheridan	3,190	3,366	.....	6,556	12,203	1.86	10	169
Other counties [a]	.....	3,567	59	3,626	10,459	2.88	21	113
Small mines	.....	17,607	.....	17,607	37,730	2.14	.....	.....
	2,561,239	105,924	122,592	2,789,755	4,526,509	1.62	3,158	201

[a] Chouteau, Missoula, and Valley.

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Coal production in Montana in 1915 and 1916—Continued.

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Carbon	1,398,223	47,482	88,562	1,534,267	1,424	299	1,723	243
Cascade	727,933	36,831	8,349	773,113	714	125	839	238
Fergus	223,696	2,635	6,350	232,681	190	70	260	278
Hill	2,500	11,950	150	14,600	18	4	22	247
Musselshell	992,226	14,145	35,636	1,042,007	664	207	871	245
Sheridan	3,600	2,473	.....	6,073	8	1	9	80
Other counties[a]	2,487	12,388	685	15,560	47	10	57	204
Small mines	.....	14,226	.....	14,226	.....	.....	.....	.....
	3,350,665	142,130	139,732	3,632,527	3,065	716	3,781	244

[a] Blaine, Chouteau, Missoula, Park, and Valley.

Value of coal produced in Montana in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Carbon	$2,785,935	$102,671	$64,082	$2,952,688	$1.92
Cascade	1,130,724	81,409	7,200	1,219,333	1.58
Fergus	328,371	6,857	3,175	338,403	1.45
Hill	6,250	29,875	150	36,275	2.48
Musselshell	1,576,731	30,523	37,372	1,644,626	1.58
Sheridan	7,200	4,945	.....	12,145	2.00
Other counties[a]	6,218	36,969	1,462	44,649	2.87
Small mines	.....	38,078	.....	38,078	2.68
	5,841,429	331,327	113,441	6,286,197	1.73
Average value per ton	1.74	2.33	.81	1.73	.....

[a] Blaine, Chouteau, Missoula, Park, and Valley.

Coal produced in Montana, 1912–1916, in net tons.

County.	1912	1913	1914	1915	1916	Increase or decrease 1916.
Carbon	1,187,270	1,304,524	1,212,941	1,172,721	1,534,267	+ 361,546
Cascade	855,576	912,634	664,423	619,745	773,113	+ 153,368
Chouteau	21,590	.....	.....	(a)	(a)	(a)
Fergus	6,251	5,348	23,104	68,362	232,681	+ 164,319
Hill	9,999	9,405	16,256	14,117	14,600	+ 483
Musselshell	913,904	963,968	850,040	887,021	1,042,007	+ 154,986
Sheridan	.....	.....	(a)	6,556	6,073	− 483
Other counties	[b] 51,098	[c] 37,896	[d] 30,183	[e] 3,626	[f] 15,560	+ [f] 11,934
Small mines	2,807	7,198	8,226	17,607	14,226	− 3,381
Total	3,048,495	3,240,973	2,805,173	2,789,755	3,632,527	+ 842,772
Total value	$5,558,195	$5,653,539	$4,913,191	$4,526,509	$6,286,197	+$1,759,688

[a] Included in "Other counties."
[b] Includes Gallatin, Missoula, Park, Rosebud, and Valley counties.
[c] Includes Blaine, Custer, Missoula, Park, Rosebud, and Valley counties.
[d] Includes Blaine, Missoula, Park, and Sheridan counties.
[e] Includes Chouteau, Missoula, and Valley counties.
[f] Includes Blaine, Chouteau, Missoula, Park, and Valley.

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NEW MEXICO.

The production of coal in New Mexico in 1916 was 3,793,011 net tons, valued at $5,580,369, a decrease in quantity of 24,929 tons, or less than 1 per cent, but an increase in value of $99,008, or nearly 2 per cent. The decrease was in the shipments of coal from the two largest fields, the Raton field in Colfax County and the Gallup field in McKinley County, in both fields largely because of decrease in demand for railroad fuel. Except in November, the supply of cars was ample, but a shortage of efficient labor was reported.

The market for coal from New Mexico was extended on the Pacific coast and to interior points that normally depend on water-borne coal, which is unavailable in any considerable quantity now because of the scarcity of ocean vessels and the advances in shipping rates.

Coal produced in New Mexico in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at the mines (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Colfax	2,115,719	15,210	800	734,713	2,866,442	$3,842,048	$1.34	2,912	264
Lincoln, Santa Fe, and Socorro	140,741	8,053	8,412	.....	157,206	467,422	2.97	286	265
McKinley	759,562	6,272	19,656	.....	785,490	1,158,309	1.47	983	259
Rio Arriba and San Juan	5,060	3,225	.....	.....	8,285	12,755	1.54	24	162
Small mines	.....	517	.....	.....	517	827	1.60	.....	.....
	3,021,082	33,277	28,868	734,713	3,817,940	5,481,361	1.44	4,205	262

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at the mines (net tons).	Total quantity (net tons).	Employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Colfax	1,975,027	17,963	540	844,083	2,837,613	2,201	927	3,128	300
Lincoln, Santa Fe, and Socorro	187,584	11,863	9,170	.....	208,617	367	94	461	301
McKinley	706,062	14,379	15,159	.....	735,600	717	194	911	261
Rio Arriba and San Juan	4,640	4,320	325	.....	9,285	19	3	22	286
Small mines	.....	1,896	.....	.....	1,896	.....	.....	.....	.....
	2,873,313	50,421	25,194	844,083	3,793,011	3,304	1,218	4,522	292

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Value of coal produced in New Mexico in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines	Total value.	Average value per ton.
Colfax	$2,862,304	$27,116	$587	$918,698	$3,809,205	$1.34
Lincoln, Santa Fe, and Socorro	519,349	20,585	18,995	.....	558,929	2.66
McKinley	1,162,037	20,356	10,642	.....	1,193,535	1.62
Rio Arriba and San Juan	7,970	6,550	569	.....	15,089	1.63
Small mines	.....	3,611	.....	.....	3,611	1.90
Average value per ton	4,552,160 1.58	78,718 1.56	30,793 1.22	918,698 1.09	5,580,369 1.47	1.47 .....

Coal produced in New Mexico, 1913–1916, in net tons.

County.	1913	1914	1915	1916	Increase or decrease, 1916.
Colfax	2,749,765	3,015,363	2,866,442	2,837,613	− 28,829
Lincoln, Santa Fe, and Socorro	120,129	[a] 145,574	157,206	208,617	+ 51,411
McKinley	824,762	706,731	785,490	735,600	− 49,890
Rio Arriba and San Juan	11,100	7,775	8,285	9,285	+ 1,000
Small mines	3,050	2,246	517	1,896	+ 1,379
Total	3,708,806	3,877,689	3,817,940	3,793,011	− 24,929
Total value	$5,401,260	$6,230,871	$5,481,361	$5,580,369	+$99,008

[a] Santa Fe and Socorro counties only.

NORTH DAKOTA.

Less than half of the coal consumed in North Dakota is mined locally. In 1915 about 520,000 tons of lignite was mined and used in the State and 820,000 tons of bituminous coal was imported from other States. The inability of the operators in other States to get cars made it difficult in 1916 for North Dakota to obtain the usual quantity of coal from sources beyond its own borders, and the demand for lignite was greatly increased, particularly in the second half of the year. The production of lignite increased 20 per cent, or from 528,078 net tons in 1915 to 634,912 tons in 1916, when the value of the output was $946,082.

Lignite produced in North Dakota in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Adams	3,223	7,379	25	10,627	$14,946	$1.41	18	231
Burke	4,600	5,400	.....	10,000	12,520	1.25	17	221
Hettinger	.....	4,182	.....	4,182	5,154	1.23	3	328
McLean	1,884	7,841	.....	9,695	14,244	1.47	13	282
Morton	16,000	33,174	850	50,024	68,796	1.38	35	239
Ward	43,576	13,130	4,800	61,506	99,942	1.62	117	242
Williams	3,916	28,529	525	32,970	51,378	1.56	32	259
Other counties[a]	285,453	19,670	11,299	316,422	444,767	1.41	355	199
Small mines	.....	32,652	.....	32,652	54,325	1.66	.....	.....
	358,622	151,957	17,499	528,078	766,072	1.45	590	219

[a] Billings, Bowman, Burleigh, Divide, Dunn, Oliver, and Stark.

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Lignite produced in North Dakota in 1915 and 1916—Continued.

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Adams	3,748	7,701	300	11,749	14	4	18	228
Burke	14,250	9,150	.....	23,400	8	7	15	230
Burleigh, McLean, and Mercer	205,389	16,368	10,804	232,561	199	48	247	262
Divide	59,333	5,888	2,650	67,871	78	23	101	268
Morton	6,335	28,486	50	34,871	26	5	31	244
Ward	61,710	8,872	3,800	74,382	97	36	133	220
Williams	5,245	37,728	120	43,093	40	11	51	256
Other counties [a]	84,742	10,827	2,500	98,069	91	27	118	212
Small mines	.....	48,916	.....	48,916	.....	.....	.....	.....
	440,752	173,936	20,224	634,912	553	161	714	244

[a] Billings, Bowman, Dunn, Hettinger, and Stark.

Value of lignite produced in North Dakota in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Adams	$8,433	$13,324	$600	$22,357	$1.90
Burke	22,288	14,572	.....	36,860	1.58
Burleigh, McLean, and Mercer	289,926	24,147	10,834	324,907	1.40
Divide	97,192	9,520	4,288	111,000	1.63
Morton	12,500	34,311	70	46,881	1.34
Ward	103,645	16,302	2,000	121,947	1.64
William	8,520	59,628	150	68,298	1.58
Other counties [a]	113,041	18,271	2,500	133,812	1.36
Small mines	.....	80,020	.....	80,020	1.64
	655,545	270,095	20,442	946,082	1.49
Average value per ton	1.49	1.55	1.01	1.49	.....

[a] Billings, Bowman, Dunn, Hettinger, and Stark.

Lignite produced in North Dakota, 1912–1916, in net tons.

County.	1912	1913	1914	1915	1916	Increase or decrease, 1916.
Adams	9,568	9,584	11,062	10,627	11,749	+ 1,122
Burke	11,950	12,175	11,750	10,000	23,400	+ 13,400
Burleigh	187,008	194,002	(a)	(a, c)	[d] 232,561	[d] 222,866
Divide	(b)	(b)	(g)	(h)	[b] 67,871	+[b] 67,871
Hettinger	11,029	7,550	5,100	[h] 4,182	(a)	(a)
McLean	.....	(a)	8,716	10,161	9,695	(d)
Morton	36,326	40,486	34,323	50,024	34,871	− 15,153
Stark	59,785	55,557	(a)	(a)	(a)	(a)
Ward	89,274	77,110	68,157	61,506	74,382	+ 12,876
Williams	22,953	27,758	38,750	32,970	43,093	+ 10,123
Other counties	[e] 41,161	[e] 45,015	[g] 298,469	[h] 316,422	[i] 98,069	−222,535
Small mines	30,426	17,367	28,913	32,652	48,916	+ 16,264
Total	499,480	495,320	506,685	528,078	634,912	+ 106,834
Total value	$765,105	$750,652	$771,379	$766,072	$946,082	+$180,010

[a] Included in "Other counties."
[b] Divide County included in "Other counties" in previous years.
[c] Burleigh County included in "Other counties" in 1915.
[d] Burleigh County includes McLean and Mercer counties.
[e] Includes Bowman, Divide, Dunn, McLean, Mercer, and Oliver counties.
[f] Includes Bowman, Divide, Mercer, and Oliver counties.
[g] Includes Billings, Bowman, Burleigh, Divide, Oliver, and Stark counties.
[h] Includes Billings, Bowman, Burleigh, Divide, Dunn, Oliver, and Stark counties.
[i] Includes Billings, Bowman, Dunn, Hettinger, and Stark counties in 1916.

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OHIO.

The progress made by the coal industry of Ohio in 1916 was as remarkable as the depression it suffered in 1914, the year of the strike. The increase in production in 1916 was 55 per cent, from 22,434,691 net tons to 34,728,219 tons. The production in 1913, the banner year, was 36,200,000 tons; in 1914 it was 18,843,000 tons. In January, February, and March, 1916, the production averaged nearly 3,000,000 tons a month. April showed a decrease of nearly half, but after the Lake season began the output increased, and in June it reached the high record for the year—more than 3,500,000 tons. From July to October an almost even rate was maintained, but in November and December there was a slight decrease. About 5,000,000 tons of coal from Ohio was shipped up the Lakes, a larger quantity of Lake coal from Ohio than in any previous year except 1913.

There was a substantial increase in the quantity of coal taken by the railroads for fuel, but increased shipments by the Lakes and increased demand from industrial plants, mainly in Ohio, were large factors in the gain. During the period of labor troubles in western Pennsylvania coal from Ohio was shipped into the Pittsburgh district to supply the shortage, and in the last quarter of the year Ohio coal was shipped by way of Buffalo to New York and New England, markets normally supplied by Pennsylvania and West Virginia.

With the exception of Carroll, Homes, Muskingum, and Stark, all counties recorded increase in output, Belmont County in the Pittsburgh No. 8 district alone contributing nearly half the total increase of the State.

It does not appear that the lack of transportation facilities was felt as much in Ohio as in other fields, probably because of the shorter average haul to market. The information available indicates that until September the supply of cars, which varied of course on different roads, was about equal to the demand, and in the last quarter it was in general 80 per cent, or better. It is probable that with the available supply of labor the production could not have been much greater, even had there been more cars. The number of men increased from 40,053, who worked an average of 142 days in 1915, to 41,394 men, who worked an average of 197 days in 1916. The average daily and annual output per man increased from 3.94 and 560 tons in 1915 to 4.26 and 839 tons in 1916.

An interesting feature was the increase in 1916 in the number and importance of the operations in which coal is recovered from shallow beds by steam shovels. The tonnage mined by that method was 551,000 in 1916, against 273,000 in 1915. These operations are conducted in the same general way as those that have been so successful in Kansas and Missouri in the last few years.

The value at the mines of the coal produced in Ohio in 1916 was $46,150,907, an increase over 1915 of $21,943,832, or 91 per cent. The average value per ton in 1916 was $1.33, against $1.08 in 1915, an increase of 23 per cent.

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Coal produced in Ohio in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Athens	2,404,428	41,200	74,860	.....	2,520,488	$2,689,132	$1.07	6,519	106
Belmont	3,947,808	313,737	43,021	.....	4,304,566	4,287,878	.99	8,202	114
Carroll	291,386	48,780	4,800	.....	344,966	391,985	1.14	563	236
Columbiana	490,476	40,661	10,725	.....	541,862	619,237	1.14	812	208
Coshocton	163,976	30,709	3,749	.....	198,434	249,880	1.26	490	145
Gallia, Morgan, and Scioto	101,593	1,762	6,025	.....	109,380	113,273	1.04	217	50
Guernsey	3,135,367	19,480	78,114	.....	3,232,961	3,211,007	.99	4,213	168
Harrison	199,134	11,053	4,443	.....	214,630	222,013	1.03	768	78
Hocking	1,161,249	79,421	23,859	.....	1,264,529	1,347,619	1.07	2,076	162
Holmes	.....	6,117	.....	.....	6,117	8,278	1.35	17	264
Jackson	452,422	87,419	25,468	.....	565,309	857,717	1.52	1,654	118
Jefferson	3,215,583	316,824	74,829	1,217	3,608,453	3,845,363	1.07	5,392	151
Lawrence	85,018	41,012	1,343	.....	127,373	145,947	1.15	307	177
Mahoning	6,984	5,172	400	.....	12,556	22,317	1.78	45	166
Medina	.....	5,596	.....	.....	5,596	11,094	1.98	15	197
Meigs	885,136	48,487	10,266	.....	943,889	992,324	1.05	1,550	207
Muskingum	330,281	52,333	4,372	.....	386,986	413,505	1.07	576	192
Noble	580,818	7,897	8,071	.....	596,786	597,179	1.00	751	174
Perry	1,070,159	46,076	20,241	.....	1,136,476	1,191,993	1.05	2,538	127
Portage and Summit	91,322	5,452	12,754	.....	109,528	219,577	2.00	240	140
Stark	206,062	129,993	15,965	.....	352,020	583,478	1.66	829	153
Tuscarawas	1,104,180	230,701	32,654	.....	1,367,535	1,511,632	1.11	1,918	203
Vinton	65,876	35,590	2,338	.....	103,804	117,597	1.13	152	215
Wayne	62,327	4,918	7,404	.....	74,649	147,192	1.97	214	153
Small mines	.....	305,798	.....	.....	305,798	409,858	1.34	.....	.....
	20,051,585	1,916,188	465,701	1,217	22,434,691	24,207,075	1.08	[illegible]0,053	142

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Athens	3,613,756	33,154	65,021	.....	3,711,931	5,377	622	5,999	157
Belmont	9,736,069	475,570	119,302	.....	10,330,941	9,913	1,039	10,952	205
Carroll	248,344	48,343	4,450	.....	301,137	425	40	465	237
Columbiana	541,836	35,702	11,989	.....	589,527	596	66	662	245
Coshocton	241,940	48,078	3,280	.....	293,298	436	72	508	184
Gallia, Morgan, and Scioto	249,761	1,707	7,560	.....	259,028	269	33	302	212
Guernsey	4,246,785	44,333	95,043	.....	4,386,161	3,907	329	4,236	213
Harrison	949,227	12,346	12,055	.....	973,628	776	125	901	188
Hocking	1,347,938	36,183	17,332	.....	1,401,453	1,520	250	1,770	196
Holmes	.....	5,180	.....	.....	5,180	13	3	16	133
Jackson	560,733	95,500	37,867	.....	694,100	1,254	183	1,437	189
Jefferson	5,081,893	349,935	100,381	720	5,532,929	4,527	793	5,320	220
Lawrence	116,462	62,334	701	.....	179,497	331	62	393	213
Mahoning	2,663	16,210	200	.....	19,073	46	11	57	207
Medina	.....	9,050	10	.....	9,060	20	4	24	242
Meigs	953,724	43,446	11,765	.....	1,008,935	1,285	245	1,530	215
Muskingum	325,545	49,039	1,702	.....	376,286	492	88	580	188
Noble	837,583	7,993	11,951	.....	857,527	768	47	815	219
Perry	1,276,392	28,195	30,172	.....	1,334,759	2,069	294	2,363	146
Portage and Summit	85,951	12,170	9,722	.....	107,843	140	41	181	171
Stark	148,180	136,988	11,213	.....	296,381	540	88	628	198
Tuscarawas	1,235,739	232,297	36,460	.....	1,504,496	1,576	232	1,808	210
Vinton	80,489	22,864	1,514	.....	104,867	168	20	188	154
Wayne	114,903	4,528	18,218	.....	137,649	232	27	259	147
Small mines	.....	312,533	.....	.....	312,533	.....	.....	.....	.....
	31,995,913	2,123,678	607,908	720	34,728,219	36,680	4,714	41,394	197

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Value of coal produced in Ohio in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Athens	$4,834,229	$40,627	$66,235	.....	$4,941,091	$1.33
Belmont	12,249,142	564,035	120,289	.....	12,933,466	1.25
Carroll	365,998	58,556	5,620	.....	430,174	1.43
Columbiana	851,323	52,924	17,898	.....	922,145	1.56
Coshocton	383,203	67,704	3,547	.....	454,544	1.55
Gallia, Morgan, and Scioto	354,348	2,906	4,080	.....	361,334	1.39
Guernsey	5,316,452	52,852	119,886	.....	5,489,190	1.25
Harrison	1,296,524	13,421	12,553	.....	1,322,498	1.36
Hocking	1,833,090	56,846	14,693	.....	1,904,629	1.36
Holmes	.....	8,297	.....	.....	8,297	1.60
Jackson	1,058,337	133,012	45,298	.....	1,236,647	1.78
Jefferson	6,555,642	478,650	100,317	648	7,135,257	1.29
Lawrence	168,063	75,238	637	.....	243,938	1.36
Mahoning	6,085	29,433	400	.....	35,918	1.88
Medina	.....	22,104	30	.....	22,134	2.44
Meigs	1,396,273	47,806	12,857	.....	1,456,936	1.44
Muskingum	387,924	73,105	1,571	.....	462,600	1.23
Noble	1,044,841	10,611	15,401	.....	1,070,853	1.25
Perry	1,747,247	34,087	30,707	.....	1,812,041	1.36
Portage and Summit	218,739	27,369	10,841	.....	256,949	2.38
Stark	371,088	231,838	15,769	.....	618,695	2.09
Tuscarawas	1,777,597	315,469	40,466	.....	2,133,532	1.42
Vinton	101,109	24,067	2,218	.....	127,394	1.21
Wayne	263,974	9,999	31,882	.....	295,855	2.15
Small mines	.....	474,790	.....	.....	474,790	1.52
	42,571,318	2,905,746	673,195	648	46,150,907	1.33
Average value per ton	1.33	1.37	1.11	.90	1.33	.....

Coal produced in Ohio, 1912–1916, in net tons.

County.	1912	1913	1914	1915	1916	Increase or decrease, 1916.
Athens	4,819,774	4,968,633	3,296,189	2,520,488	3,711,931	+ 1,191,443
Belmont	9,382,330	10,436,259	2,849,181	4,304,566	10,330,941	+ 6,026,375
Carroll	322,969	379,064	235,480	344,966	301,137	− 43,829
Columbiana	448,778	522,804	342,366	541,862	589,527	+ 47,665
Coshocton	371,399	364,411	153,046	198,434	293,298	+ 94,864
Gallia, Morgan, and Scioto	294,860	298,744	207,924	109,380	259,028	+ 149,648
Guernsey	4,246,955	4,321,992	2,936,707	3,252,961	4,386,161	+ 1,153,200
Harrison	812,953	730,221	184,892	214,630	973,028	+ 758,998
Hocking	1,763,177	1,678,623	1,231,340	1,264,529	1,401,453	+ 136,924
Holmes	10,257	8,987	8,934	6,117	5,180	− 937
Jackson	737,284	587,044	532,831	565,309	694,100	+ 128,791
Jefferson	4,858,529	5,178,922	2,172,881	3,608,453	5,532,929	+ 1,924,476
Lawrence	66,158	176,098	160,077	127,373	179,497	+ 52,124
Mahoning	33,194	15,796	15,908	12,556	19,073	+ 6,517
Medina, Portage, and Summit	[a] 172,079	[a] 158,174	125,063	115,124	116,903	+ 1,779
Meigs	644,463	642,725	534,784	943,889	1,008,935	+ 65,046
Muskingum	465,629	472,748	328,329	386,986	376,286	− 10,700
Noble	624,404	787,141	501,942	596,786	857,527	+ 260,741
Perry	2,145,916	2,177,564	1,186,674	1,136,476	1,334,759	+ 198,283
Stark	414,452	417,238	457,983	352,020	296,381	− 55,639
Tuscarawas	1,324,594	1,419,922	921,236	1,367,535	1,504,496	+ 136,961
Vinton	97,938	122,492	84,372	103,804	104,867	+ 1,063
Wayne	194,086	97,233	88,345	74,649	137,649	+ 63,000
Small mines	276,599	237,702	284,686	305,798	312,533	+ 6,735
Total	34,528,727	36,200,527	18,843,115	22,434,691	34,728,219	+ 12,293,528
Total value	$37,063,363	$39,948,058	$21,250,642	$24,207,075	$46,150,907	+$21,943,832

[a] Includes Trumbull County.

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OKLAHOMA.

The production of coal in Oklahoma in 1916 was 3,608,011 net tons, a decrease compared with 1915 of 85,569 tons, or 2 per cent. The value at the mine of the coal produced in 1916 was $7,525,427, an increase of $89,521, or 1 per cent.

Production was curtailed by lack of business during the early part of the year at a time when most other coal fields were producing at a high rate. The demand for coal improved after September 1, but labor troubles resulted in a temporary shutting down of the mines, and on some of the railroads there was a shortage of cars. Scarcity of labor was a large factor in the decreased output, the number of men employed in 1916 having been but 7,800, compared with 8,457 in 1915.

Coal produced in Oklahoma in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Coal	527,833	8,800	19,846	556,479	$1,295,281	$2.20	1,663	161
Latimer	620,715	6,746	113,408	740,869	1,373,126	1.85	1,274	198
Le Flore	240,797	3,003	12,842	256,642	409,818	1.60	550	182
Okmulgee	857,256	1,394	10,594	869,244	1,496,601	1.72	1,690	157
Pittsburg	1,037,219	6,285	88,768	1,132,272	2,061,618	2.35	2,961	159
Tulsa	93,693	1,537	930	96,160	182,914	1.90	195	225
Other counties [a]	16,987	3,287	669	20,943	43,248	2.07	69	119
Small mines [b]	12,033	8,430	508	20,971	42,300	2.06	55	45
	3,406,533	39,482	247,565	3,693,580	7,435,906	2.01	8,457	167

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Coal	501,011	5,535	18,408	524,954	1,056	114	1,170	194
Latimer	759,651	4,461	46,392	810,504	1,308	199	1,507	200
Le Flore	250,928	2,458	12,776	266,162	454	106	560	169
Okmulgee	836,248	2,507	13,451	852,206	1,521	246	1,767	180
Pittsburg	881,495	10,985	84,563	977,043	1,980	369	2,349	165
Tulsa	57,601	1,764	365	59,730	154	18	172	159
Other counties [c]	108,429	2,447	2,693	113,569	147	128	275	138
Small mines	.....	3,843	.....	3,843	.....	.....	.....	.....
	3,395,363	34,000	178,648	3,608,011	6,620	1,180	7,800	178

[a] Rogers and Wagoner.
[b] Includes Atoka County.
[c] Atoka, Haskell, Rogers, and Wagoner

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Value of coal produced in Oklahoma in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Coal	$1,104,181	$15,356	$33,209	$1,152,746	$2.20
Latimer	1,650,128	9,317	73,834	1,733,279	2.14
Le Flore	434,772	4,823	17,207	456,802	1.72
Okmulgee	1,507,374	6,410	15,295	1,529,079	1.79
Pittsburg	2,127,114	26,964	133,346	2,287,424	2.34
Tulsa	123,598	4,223	730	128,551	2.15
Other counties [a]	217,191	6,543	4,360	228,094	2.01
Small mines	.....	9,452	.....	9,452	2.46
	7,164,358	83,088	277,981	7,525,427	2.09
Average value per ton	2.11	2.44	1.56	2.09	.....

[a] Includes Atoka, Haskell, Rogers, and Wagoner counties.

Coal produced in Oklahoma in 1912–1916, in net tons.

County.	1912	1913	1914	1915	1916	Increase or decrease, 1916.
Atoka and Haskell	.....	.....	.....	.....	82,752	+ 82,752
Coal	816,155	889,209	676,292	556,479	524,954	− 31,525
Haskell and Latimer	766,798	738,679	[a] 666,274	[a] 740,869	[a] 810,504	+[a]69,635
Le Flore	150,511	201,853	264,023	256,642	266,162	+ 9,520
Okmulgee	629,989	820,659	905,128	869,244	852,206	− 17,038
Pittsburg	1,234,334	1,429,350	1,373,771	1,132,272	977,043	−155,229
Rogers and Wagoner	30,126	31,067	29,568	20,943	30,817	+ 9,874
Tulsa	39,964	52,300	68,792	96,160	59,730	− 36,430
Small mines	[b] 7,541	2,563	[c] 4,765	[b] 20,971	3,843	− 17,128
Total value	3,675,418	4,165,770	3,988,613	3,693,580	3,608,011	− 85,569
	$7,867,331	$8,542,748	$8,204,015	$7,435,906	$7,525,427	+$89,521

[a] Latimer County only. [b] Includes Atoka County. [c] Includes Tulsa County.

OREGON.

The production of coal in Oregon increased from 39,231 tons in 1915 to 42,592 tons in 1916. The value at the mines increased from $111,240 to $113,976, but the average value per ton decreased from $2.84 to $2.68.

Coal produced in Oregon, 1912–1916.

Year.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
1912	14,361	19,646	7,630	41,637	$108,276	$2.60	222	239
1913	31,582	8,617	5,864	46,063	116,724	2.53	208	263
1914	37,152	5,798	6,608	51,558	143,556	2.78	190	266
1915	30,142	2,272	6,817	39,231	111,240	2.84	151	206
1916	28,373	7,482	6,737	42,592	113,976	2.68	106	236

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PENNSYLVANIA.

PENNSYLVANIA ANTHRACITE.

Anthracite produced in 1915 and 1916.

Region.	Shipments.		Sold to local trade and employees.		Mine fuel.		Total production.		Men employed.			Average number of days worked.
	Gross tons.	Value.	Gross tons.	Value.	Gross tons.	Value.	Gross tons.	Value.	Underground.	Surface.	Total.	
1915.												
Lehigh:												
Freshly mined coal	9,942,142	.....	249,669	.....	1,307,397	.....	11,499,208	826,657,216	.....	.....	22,563	.....
Washery product	248,279	.....	4,445	.....	97,319	.....	350,043	385,867	.....	.....	232	.....
	10,190,421	.....	254,114	.....	1,404,716	.....	11,849,251	27,043,083	.....	.....	22,795	.....
Schuylkill:												
Freshly mined coal	17,415,089	.....	376,671	.....	3,066,086	.....	20,877,846	46,526,194	.....	.....	51,406	.....
Washery product	611,221	.....	4,051	.....	145,320	.....	760,622	685,685	.....	.....	533	.....
Dredge product	17,399	.....	63,198	.....	42,893	.....	123,490	100,569	.....	.....	128	.....
	18,043,709	.....	443,950	.....	3,274,299	.....	21,761,958	47,312,448	.....	.....	52,067	.....
Wyoming:												
Freshly mined coal	38,329,604	.....	1,077,943	.....	3,652,068	.....	43,059,615	107,594,066	.....	.....	99,759	.....
Washery product	1,615,640	.....	82,706	.....	550,203	.....	2,248,549	1,698,102	.....	.....	869	.....
Dredge product	100	.....	.....	.....	.....	.....	100	175	.....	.....	5	.....
	39,945,344	.....	1,160,649	.....	4,202,271	.....	45,308,264	109,292,343	.....	.....	100,633	.....
Sullivan County:												
Freshly mined coal	496,982	.....	9,221	.....	44,200	.....	540,403	1,005,624	.....	.....	1,057	.....
Total freshly mined coal	66,173,817	.....	1,713,504	.....	8,089,751	.....	75,977,072	181,783,100	.....	.....	174,785	.....
Total washery product	2,475,140	.....	91,232	.....	792,842	.....	3,359,214	2,769,654	.....	.....	1,634	.....
Total dredge product	17,499	.....	63,198	.....	42,893	.....	123,590	100,744	.....	.....	133	.....
Grand total	68,666,456	.....	1,867,934	.....	8,925,486	.....	79,459,876	184,653,498	.....	.....	176,552	280

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1916.												
Lehigh:												
Freshly mined coal	9,125,745	$25,944,901	269,686	$499,231	1,153,480	$661,116	10,548,911	27,105,248	13,185	6,119	19,304	262
Washery product	311,800	556,834	3,650	4,946	64,694	33,226	380,144	595,006	.....	211	211	105
	9,437,545	26,501,735	273,336	504,177	1,218,174	694,342	10,929,055	27,700,254	13,185	6,330	19,515	261
Schuylkill:												
Freshly mined coal	18,577,444	52,863,290	308,889	1,007,061	3,280,583	1,249,388	22,256,916	55,119,739	32,801	14,204	47,005	254
Washery product	1,073,137	1,379,144	372	856	189,494	99,199	1,263,003	1,479,199	.....	741	741	236
Dredge product	26,895	20,976	58,425	59,357	54,209	24,891	139,529	105,224	.....	118	118	175
	19,677,476	54,263,410	457,686	1,067,274	3,524,286	1,373,478	23,659,448	56,704,162	32,801	15,063	47,864	254
Wyoming:												
Freshly mined coal	36,223,557	109,757,517	1,155,534	2,953,453	3,354,968	1,682,018	40,734,059	114,392,988	70,022	20,474	90,496	252
Washery product	1,719,277	1,904,169	81,422	68,153	573,193	264,355	2,373,392	2,236,677	21	971	992	231
Dredge product	2,500	2,875	961	2,582	300	150	3,781	5,607	7	53	60	153
	37,945,334	111,664,561	1,237,937	3,024,188	3,928,461	1,946,523	43,111,732	116,635,272	70,050	21,498	91,548	252
Sullivan County:												
Freshly mined coal	441,006	907,181	9,690	23,717	44,150	38,975	494,848	969,873	669	273	942	223
Total freshly mined coal	64,367,754	189,472,889	1,833,799	4,483,462	7,833,181	3,631,497	74,034,734	197,587,848	116,677	41,070	157,747	.....
Total washery product	3,104,214	3,840,147	85,444	73,955	827,381	396,780	4,017,039	4,310,882	21	1,923	1,944	219
Total dredge product	29,395	23,851	59,406	61,939	54,509	25,041	143,310	110,831	7	171	178	168
Grand total	[a] 67,501,363	193,336,887	1,978,649	4,619,356	8,715,071	4,053,318	78,195,083	202,009,561	116,705	43,164	159,869	253

[a] Includes 24,286 tons of coal sold locally and not shipped and 2,090 tons used as fuel.

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Anthracite produced in 1890–1916.

Year.	Quantity (gross tons).	Value.	Year.	Quantity (gross tons).	Value.
1890	41,489,858	a$66,383,772	1912	75,322,855	$177,622,626
1895	51,785,122	a 82,019,272	1913	81,718,680	195,181,127
1900	51,221,353	a 85,757,851	1914	81,090,631	188,181,389
1905	69,339,152	a 141,879,000	1915	79,459,876	184,653,466
1910	75,433,246	160,275,302	1916	78,195,083	202,009,551
1911	80,771,488	175,189,392			

a Excludes value of coal used at collieries.

Anthracite shipped in 1915 and 1916, by regions and sizes, in gross tons.

Size.	Lehigh region.		Schuylkill region.		
	Mines.	Washeries.	Mines.	Washeries.	Dredges.
1915.					
Lump	7,789	.....	60,057	0	0
Broken	489,714	.....	786,538	0	0
Egg	1,249,187	.....	1,999,081	288	0
Stove	1,884,537	2,399	3,326,849	6,699	50
Chestnut	2,028,881	31,037	3,644,953	24,518	3
Pea	1,295,741	43,162	2,288,264	65,578	28
Buckwheat No. 1	1,420,566	42,144	3,069,620	133,285	1,716
Buckwheat No. 2	938,954	58,255	1,495,395	159,137	8,980
Buckwheat No. 3	568,230	71,282	608,578	189,839	8,482
Screenings	58,543	.....	135,754	31,877	3,230
	9,942,142	248,279	17,415,089	611,221	17,309
1916.					
Lump	6,598	0	86,984	0	0
Broken	422,134	0	884,671	0	0
Egg	1,168,670	5,220	2,097,981	214	0
Stove	1,782,280	7,885	3,435,862	7,562	109
Chestnut	1,895,311	58,447	3,810,027	46,704	0
Pea	1,119,934	50,685	2,380,968	134,307	233
Buckwheat No. 1	1,304,711	39,252	3,435,643	302,013	3,799
Buckwheat No. 2	627,820	52,546	1,328,136	236,254	2,668
Buckwheat No. 3	502,521	92,135	712,191	211,321	14,730
Boiler	264,044	5,690	283,983	94,666	0
Other	31,722	0	120,996	40,096	5,350
	9,125,745	311,800	18,577,444	1,073,137	26,895

Size.	Wyoming region.			Sullivan County.	Total.	Per cent of total.
	Mines.	Washeries.	Dredges.	Mines.		
1915.						
Lump	47,502	0	0	.....	115,348	0.2
Broken	2,060,375	0	0	13,306	3,349,933	4.9
Egg	4,823,313	0	0	44,971	8,117,340	11.8
Stove	8,768,426	9	0	72,100	14,061,069	20.4
Chestnut	9,727,135	23,187	0	90,299	15,570,013	22.7
Pea	4,369,653	39,956	10	58,276	8,210,668	11.9
Buckwheat No. 1	4,446,574	208,628	0	.....	9,322,533	13.6
Buckwheat No. 2	2,337,437	562,430	0	.....	5,560,498	8.1
Buckwheat No. 3	1,678,336	716,288	90	.....	3,836,125	5.6
Screenings	70,353	15,142	0	208,030	522,929	.8
	38,329,604	1,615,640	100	486,982	68,666,456	100.0
1916.						
Lump	25,980	0	0	0	119,562	0.2
Broken	2,226,024	0	0	10,497	3,543,326	5.2
Egg	5,170,966	257	0	43,704	8,487,032	12.6
Stove	8,298,618	486	0	66,003	13,598,796	20.1
Chestnut	9,072,939	45,071	0	70,000	14,996,499	22.2
Pea	3,669,496	112,051	0	53,131	7,520,804	11.1
Buckwheat No. 1	4,176,258	267,150	1,000	40,000	9,569,817	14.2
Buckwheat No. 2	1,619,390	694,941	1,000	20,000	4,582,720	6.8
Buckwheat No. 3	1,266,882	521,760	500	20,000	3,342,040	5.0
Boiler	661,539	77,236	0	7,778	1,304,876	2.1
Other	35,505	325	0	109,895	343,891	.5
	36,223,557	1,719,277	2,500	441,008	67,501,363	100.0

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Anthracite shipped in 1915 and 1916, by sizes, in gross tons.

	1915			1916		
	From mines.	From washeries and dredges.	Total.	From mines.	From washeries and dredges.	Total.
Lump and steamboat	115,348	.....	115,348	119,562	.....	119,562
Broken	3,349,933	.....	3,349,933	3,543,326	.....	3,543,326
Egg	8,117,052	288	8,117,340	8,481,341	5,691	8,487,032
Stove	14,051,912	9,157	14,061,069	13,582,763	16,033	13,598,796
Chestnut	15,491,268	78,745	15,570,013	14,848,277	150,222	14,998,499
Pea	8,011,934	198,734	8,210,668	7,223,529	297,275	7,520,804
Buckwheat No. 1	8,936,760	385,773	9,322,533	8,956,612	613,205	9,569,817
Buckwheat No. 2 (rice)	4,771,786	788,712	5,560,498	3,595,286	987,434	4,582,720
Buckwheat No. 3 (barley)	2,855,144	980,981	3,836,125	2,501,594	840,446	3,342,040
Boiler	(a)	(a)	(a)	1,217,344	177,532	1,394,876
Other (screenings, culm, etc.)	472,680	50,249	522,929	298,120	45,771	343,891
	66,173,817	2,492,639	68,666,456	64,367,754	3,133,609	67,501,363

a Included with "Other."

Value of anthracite shipped in 1916, by regions and sizes.

Size.	Lehigh region.				Schuylkill region.					
	Mines.	Average value.	Washeries.	Average value.	Mines.	Average value.	Washeries.	Average value.	Dredges.	Average value.
Lump	$26,331	$3.99	$0	$0	$293,531	$3.37	$0	$0	$0	$0
Broken	1,349,753	3.20	0	0	2,925,979	3.21	0	0	0	0
Egg	4,390,201	3.76	19,636	3.76	7,895,656	3.76	685	3.20	0	0
Stove	6,933,405	3.89	31,559	4.00	13,703,757	3.99	28,507	3.77	377	3.77
Chestnut	7,586,884	4.00	233,220	3.99	15,562,132	4.08	201,198	4.31	0	0
Pea	2,702,897	2.41	118,806	2.34	5,786,791	2.43	328,046	2.44	183	.79
Buckwheat No. 1	1,822,326	1.40	49,587	1.26	4,398,092	1.43	423,669	1.40	4,029	1.06
Buckwheat No. 2	556,741	.89	41,501	.79	1,147,333	.86	197,295	.84	2,693	1.00
Buckwheat No. 3	325,974	.65	58,796	.64	434,174	.61	119,304	.56	9,166	.62
Boiler	243,396	.92	3,729	.66	170,207	.60	63,410	.67	0	0
Other	7,091	.22	0	0	45,638	.38	17,080	.42	4,528	.85
	25,944,901	2.84	556,834	1.79	52,863,290	2.85	1,379,144	1.29	20,976	.78

Size.	Wyoming region.						Sullivan County.		Total.	
	Mines.	Average value.	Washeries.	Average value.	Dredges.	Average value.	Mines.	Average value.		Average value.
Lump	$76,802	$2.96	$0	$0	$0	$0	$0	$0	$396,664	$3.32
Broken	7,121,270	3.20	0	0	0	0	31,864	3.04	11,428,866	3.23
Egg	19,139,198	3.70	951	3.70	0	0	124,390	2.85	31,570,717	3.72
Stove	30,915,946	3.73	1,817	3.74	0	0	181,393	2.75	51,796,761	3.81
Chestnut	34,972,749	3.85	176,601	3.92	0	0	187,253	2.68	58,920,067	3.93
Pea	8,381,511	2.28	262,419	2.34	0	0	109,768	2.07	17,690,421	2.35
Buckwheat No. 1	6,384,965	1.53	397,833	1.49	1,150	1.15	73,600	1.84	14,055,241	1.47
Buckwheat No. 2	1,529,585	.94	695,267	1.00	1,150	1.15	36,800	1.84	4,208,365	.92
Buckwheat No. 3	738,616	.58	309,779	.59	575	1.15	36,800	1.84	2,033,184	.61
Boiler	485,377	.73	59,421	.77	0	0	14,294	1.84	1,039,736	.75
Other	11,508	.32	81	.25	0	0	110,989	1.01	196,865	.57
	109,757,517	3.03	1,904,169	1.11	2,875	1.15	907,181	2.06	193,336,887	2.86

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Anthracite shipped in 1912–1916, by months, in gross tons.

Month.	1912[a]	1913[a]	1914[a]	1915	1916
January	5,763,696	6,336,419	5,175,732	4,833,509	5,884,350
February	5,875,966	5,674,169	4,121,451	4,349,915	5,696,306
March	6,569,687	4,909,286	5,164,708	5,075,298	6,127,351
April	266,625	5,966,189	6,072,164	6,655,625	4,528,784
May	1,429,357	5,995,742	6,281,553	5,954,949	5,547,899
June	6,191,646	5,970,047	6,130,186	5,459,610	5,636,975
July	6,285,153	5,487,853	5,391,857	5,103,665	5,432,873
August	6,576,591	5,369,900	5,483,743	5,462,127	5,531,797
September	5,876,406	5,572,279	6,246,192	5,662,157	5,544,076
October	6,665,821	6,338,194	6,644,476	6,683,007	5,870,204
November	6,165,536	5,786,981	5,928,286	6,494,442	5,992,997
December	5,944,502	5,662,618	5,702,258	6,149,387	5,582,747
	63,610,578	69,069,628	68,342,601	67,883,776	67,376,364

[a] The figures for the Lehigh & New England R. R. are not included in 1912, 1913, and 1914, and the totals for these years are therefore not comparable with 1915 and 1916.

Anthracite shipped from the Schuylkill, Lehigh, and Wyoming regions in 1807 and from 1820 to 1916, in gross tons.

Year.	Schuylkill region.		Lehigh region.		Wyoming region.		Total.
	Quantity.	Percentage.	Quantity.	Percentage.	Quantity.	Percentage.	Quantity.
1807					55		55
1820			365				365
1821			1,073				1,073
1822	1,480	39.79	2,240	60.21			3,720
1823	1,128	16.23	5,823	83.77			6,951
1824	1,567	14.10	9,541	85.90			11,108
1825	6,500	18.60	28,398	81.40			34,898
1826	16,767	34.90	31,280	65.10			48,047
1827	31,360	49.44	32,074	50.56			63,434
1828	47,284	61.00	30,232	39.00			77,516
1829	79,973	71.35	25,110	22.40	7,000	6.25	112,083
1830	89,984	51.50	41,750	23.90	43,000	24.60	174,734
1831	81,854	46.29	40,966	23.17	54,000	30.54	176,820
1832	209,271	57.61	70,000	19.27	84,000	23.12	363,271
1833	252,971	51.87	123,001	25.22	111,777	22.91	487,749
1834	226,902	60.19	106,244	28.21	43,700	11.60	376,886
1835	330,508	60.54	131,250	23.41	90,000	16.05	560,758
1836	432,045	63.16	148,211	21.66	103,861	15.18	684,117
1837	530,152	60.98	223,902	25.75	115,387	13.27	869,441
1838	446,875	60.49	213,615	28.92	78,207	10.59	738,697
1839	475,077	58.05	221,025	27.01	122,300	14.94	818,402
1840	490,596	56.75	225,313	26.07	148,470	17.18	864,379
1841	624,466	65.07	143,037	14.90	192,270	20.03	959,773
1842	583,273	52.62	272,540	24.59	252,599	22.79	1,108,412
1843	710,200	56.21	267,793	21.19	285,605	22.60	1,263,598
1844	887,987	54.45	377,002	23.12	365,911	22.43	1,630,950
1845	1,131,724	56.22	429,453	21.33	451,836	22.45	2,013,013
1846	1,308,500	55.82	517,116	22.07	518,389	22.11	2,344,005
1847	1,665,735	57.79	633,507	21.98	583,057	20.23	2,882,299
1848	1,733,721	56.12	670,321	21.70	685,196	22.18	3,089,238
1849	1,728,500	53.30	781,556	24.10	732,910	22.60	3,242,966
1850	1,840,620	54.80	690,456	20.56	827,823	24.64	3,358,899
1851	2,328,525	52.34	964,224	21.68	1,156,167	25.98	4,448,916
1852	2,696,935	52.81	1,072,136	21.47	1,294,500	25.72	4,993,471
1853	2,955,110	51.30	1,054,309	20.29	1,476,732	28.41	5,196,151
1854	3,191,670	53.14	1,207,186	20.13	1,608,478	26.73	6,003,334
1855	3,552,943	53.77	1,284,113	19.43	1,771,511	26.80	6,606,567
1856	3,608,029	52.01	1,351,970	19.52	1,972,581	28.47	6,927,580
1857	3,373,797	50.77	1,318,541	19.84	1,952,608	29.39	6,644,946
1858	3,273,245	47.86	1,380,030	20.18	2,186,094	31.96	6,839,369
1859	3,448,708	44.16	1,628,311	20.86	2,731,236	34.98	7,808,255
1860	3,749,632	44.04	1,821,674	21.40	2,941,817	34.56	8,513,123

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Anthracite shipped from the Schuylkill, Lehigh, and Wyoming regions in 1807 and from 1820 to 1916, in gross tons—Continued.

Year.	Schuylkill region.		Lehigh region.		Wyoming region.		Total.
	Quantity.	Percentage.	Quantity.	Percentage.	Quantity.	Percentage.	Quantity.
1861	3,160,747	39.74	1,738,377	21.85	3,055,140	38.41	7,954,264
1862	3,372,583	42.86	1,351,054	17.17	3,145,770	39.97	7,869,407
1863	3,911,683	40.90	1,894,713	19.80	3,759,610	39.30	9,566,006
1864	4,161,970	40.39	2,054,669	20.19	3,960,836	38.92	10,177,475
1865	4,356,959	45.14	2,040,913	21.14	3,254,519	33.72	9,652,391
1866	5,787,902	45.56	2,179,364	17.15	4,736,616	37.29	12,703,882
1867	5,161,671	39.74	2,502,054	19.27	5,325,000	40.99	12,988,725
1868	5,380,737	38.62	2,592,582	18.13	5,968,146	43.25	13,801,465
1869	5,775,138	41.66	1,949,673	14.06	6,141,369	44.28	13,866,180
1870	4,968,157	30.70	3,239,374	20.02	7,974,660	49.28	16,182,191
1871	6,552,772	41.74	2,235,707	14.24	6,911,242	44.02	15,699,721
1872	6,694,890	34.06	3,873,339	19.70	9,101,549	46.27	19,669,778
1873	7,212,601	33.97	3,705,596	17.46	10,309,755	48.57	21,227,952
1874	6,866,877	34.09	3,773,836	18.73	9,504,408	47.18	20,145,121
1875	6,281,712	31.87	2,834,605	14.38	10,596,155	53.75	19,712,472
1876	6,221,934	33.63	3,854,919	20.84	8,424,158	45.53	18,501,011
1877	8,195,042	39.35	4,332,760	20.80	8,300,377	39.85	20,828,179
1878	6,282,226	35.68	3,237,449	18.40	8,085,587	45.92	17,605,262
1879	8,960,829	34.28	4,595,567	17.58	12,596,293	48.14	26,142,689
1880	7,554,742	32.23	4,463,221	19.05	11,419,279	48.72	23,437,242
1881	9,253,958	32.46	5,294,676	18.58	13,951,383	48.96	28,500,017
1882	9,459,288	32.48	5,689,437	19.54	13,971,371	47.98	29,120,096
1883	10,074,726	31.69	6,113,809	19.23	15,604,492	49.08	31,793,027
1884	9,478,314	30.85	5,562,226	18.11	15,677,753	51.04	30,718,293
1885	9,488,426	30.01	5,898,634	18.65	16,236,470	51.34	31,623,530
1886	9,331,407	29.19	5,723,129	17.81	17,031,826	53.00	32,136,362
1887	10,609,028	30.63	4,347,061	12.55	19,684,929	56.82	34,641,018
1888	10,654,116	27.93	5,539,236	14.78	21,852,366	57.29	38,145,718
1889	10,486,185	29.28	6,294,073	17.57	19,036,835	53.15	35,817,093
1890	10,867,822	29.68	6,329,658	17.28	19,417,979	53.04	36,615,459
1891	12,741,258	31.50	6,381,838	15.78	21,325,240	52.72	40,448,336
1892	12,626,784	30.14	6,451,076	15.40	22,815,480	54.46	41,893,340
1893	12,257,444	28.68	6,892,352	15.99	23,839,741	55.33	43,089,537
1894	12,035,005	29.08	6,705,434	16.20	22,650,761	54.72	41,391,200
1895	14,269,932	30.68	7,298,124	15.69	24,943,421	53.63	46,511,477
1896	13,097,571	30.34	6,490,441	15.03	23,589,473	54.63	43,177,485
1897	12,181,061	29.26	6,249,540	15.00	23,207,268	55.74	41,637,864
1898	12,078,875	28.83	6,253,109	14.92	23,567,767	56.25	41,899,751
1899	14,199,009	29.79	6,887,909	14.45	26,578,296	55.76	47,665,204
1900	13,502,732	29.94	6,918,627	15.33	24,686,125	54.73	45,107,484
1901	16,019,591	29.92	7,211,974	13.45	30,337,036	56.63	53,568,601
1902	8,471,391	27.15	3,470,736	11.12	19,258,763	61.73	31,200,890
1903	16,474,790	27.75	7,164,783	12.07	35,723,258	60.18	59,362,831
1904 a	16,379,293	28.49	7,107,220	12.36	34,006,009	59.15	57,492,522
1905	17,703,099	28.83	7,849,205	12.78	35,857,897	58.39	61,410,201
1906	16,011,285	28.75	7,046,617	12.65	32,640,693	58.60	55,698,595
1907	20,141,288	30.01	8,329,653	12.41	38,638,452	57.58	67,109,393
1908	18,006,464	27.85	7,786,255	12.04	38,872,295	60.11	64,665,014
1909	16,864,147	27.21	7,532,271	12.16	37,573,467	60.63	61,969,885
1910	17,845,020	27.49	8,627,589	13.29	38,433,227	59.22	64,905,786
1911	19,118,300	27.38	9,682,147	13.86	41,033,354	58.76	69,833,801
1912	18,213,960	28.16	8,800,125	13.61	37,653,164	58.23	64,667,249
1913	19,417,385	27.44	10,180,021	14.39	41,160,906	58.17	70,758,312
1914	19,416,586	26.33	10,272,308	14.69	41,258,463	58.98	69,947,357
1915	18,043,709	26.46	10,190,421	14.95	39,945,344	58.59	68,179,474
1916	19,677,476	29.34	9,437,545	14.07	37,945,335	56.59	67,060,356
	670,257,151	31.03	332,045,664	15.37	1,157,540,175	53.60	2,159,842,990

a 1904–1916, inclusive of dredge shipments.

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PENNSYLVANIA BITUMINOUS.

The production of bituminous coal in Pennsylvania in 1916 was 170,295,424 net tons, an increase compared with 1915 of 12,340,287 tons, or nearly 8 per cent. The largest factor in this increase was the activity of the iron and steel industry, which resulted in a tremendous demand for coke. The coal made into coke, both beehive and by-product, in Pennsylvania was 5,656,833 tons more in 1916 than in 1915, and additional quantities were shipped to the new by-product ovens in Ohio. Railroad and general industrial demand also broke all records.

Car shortage, insufficient labor supply, labor disturbances, and a lowering of the efficiency of the labor all restricted the production to such an extent that at times the mines of Pennsylvania were not able to supply even the most urgent demands of their normal markets. Coal from Ohio, Indiana, and Illinois was shipped into Pennsylvania, New York, and southern New England in quantities and necessarily at a cost heretofore not considered possible.

Lack of transportation from mine to market was the most potent check on output. In the last quarter of 1915 and the first month of 1916 there was a marked shortage of cars. A temporary lull in demand in April relieved conditions somewhat, and from May to August the supply of cars was more nearly normal. From September to the end of the year, as the demand for coal increased, the car shortage continued to become worse. Scarcity of labor was most apparent during the summer, when cars were more readily to be had, but the indications are that there was in reality no improvement in the supply of men as the year progressed, and that had transportation not failed a notable shortage of labor would have held down production. Central Pennsylvania was more seriously affected by scarcity of labor and labor troubles than the other bituminous fields of the State.

The number of men employed in the mining of bituminous coal in Pennsylvania in 1916 was 168,212 compared with 174,593 in 1915, a decrease of 3.7 per cent. The gain in working time was greater, however, from 226 days in 1915 to 259 in 1916, an increase of 14 per cent. The average annual output per man increased 107 tons, from 905 tons in 1915 to 1,012 in 1916, but the average daily output per man was 3.91 tons in 1916 against 4.00 in 1915.

The value at the mine of the bituminous coal produced in Pennsylvania in 1916 was $221,685,175, an increase compared with 1915 of $54,265,470, or 32 per cent. The average value per ton increased from $1.06 in 1915 to $1.30 in 1916, about 22.6 per cent.

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Bituminous coal produced in Pennsylvania in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Allegheny	16,519,220	636,638	259,595	2,362	17,417,815	18,855,348	$1.08	20,478	221
Armstrong	4,939,692	64,416	155,774	.....	5,159,882	5,209,589	1.01	6,337	202
Beaver	61,075	25,476	1,340	.....	87,891	119,736	1.36	153	222
Bedford	489,416	12,331	6,828	127,216	635,791	683,258	1.07	883	218
Blair	287,873	341	8,725	11,602	308,541	379,325	1.23	497	190
Bradford and Lycoming	39,870	9,323	1,711	.....	50,904	89,383	1.76	99	243
Butler	977,645	34,825	24,407	.....	1,036,877	1,112,187	1.07	1,514	204
Cambria	16,430,421	891,570	312,048	1,082,412	18,716,451	21,755,913	1.16	23,072	223
Cameron and McKean	37,684	9,014	313	.....	47,011	64,555	1.37	82	260
Center	1,402,648	21,458	6,643	.....	1,430,749	1,444,473	1.01	1,902	217
Clarion	1,260,717	9,582	20,870	.....	1,291,119	1,326,430	1.03	1,737	214
Clearfield	7,210,091	164,158	243,170	405,475	8,022,894	8,543,730	1.06	11,309	218
Clinton	346,166	10,776	2,333	.....	359,275	447,434	1.25	406	222
Elk	995,687	36,063	13,804	.....	1,045,554	1,155,692	1.11	1,657	219
Fayette	6,905,608	225,839	537,992	20,754,628	28,424,067	29,207,580	1.03	24,427	260
Greene	470,635	5,004	23,509	46,860	546,008	612,039	1.12	514	281
Huntingdon	936,096	6,968	19,648	48,038	1,010,750	1,307,728	1.29	1,445	258
Indiana	9,174,284	52,565	183,750	143,258	9,553,857	9,509,221	.99	11,129	208
Jefferson	3,722,927	46,069	146,212	980,201	4,895,409	5,202,517	1.06	5,989	217
Lawrence	119,475	2,609	9,662	.....	131,746	171,157	1.30	229	268
Mercer	656,209	6,285	31,917	.....	694,411	833,255	1.20	1,083	228
Somerset	10,016,230	102,115	225,024	.....	10,343,369	11,581,969	1.12	11,198	230
Tioga	753,017	26,564	8,422	.....	788,003	1,254,624	1.59	1,708	196
Washington	14,634,678	108,934	297,657	857,450	15,898,719	16,681,842	1.05	20,019	205
Westmoreland	20,788,979	557,553	507,161	8,038,868	29,892,561	29,598,530	.99	26,726	236
Small mines	.....	165,483	.....	.....	165,483	182,176	1.10	.....	.....
	119,176,343	3,231,909	3,048,515	32,498,370	157,955,137	167,419,705	1.06	174,593	226

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked
						Underground.	Surface.	Total.	
Allegheny	15,915,161	638,181	452,408	1,661	17,007,431	15,319	2,128	17,447	237
Armstrong	5,115,517	158,939	155,732	.....	5,430,188	5,111	990	6,101	246
Beaver	34,405	56,098	1,050	.....	91,553	118	16	134	244
Bedford	546,953	14,581	12,258	147,795	721,587	1,022	136	1,158	231
Blair	377,163	1,884	11,920	44,825	435,792	514	67	581	255
Bradford and Lycoming	35,004	2,809	1,192	.....	39,005	55	25	80	258
Butler	1,091,775	57,670	30,563	.....	1,180,008	1,252	215	1,467	234
Cambria	16,833,310	1,121,485	304,568	1,328,987	19,588,350	19,034	2,322	21,356	252
Cameron and McKean	23,590	5,138	131	.....	28,859	55	15	70	294
Center	1,728,385	88,880	1,742	.....	1,819,007	1,917	224	2,141	256
Clarion	1,256,550	86,601	25,293	.....	1,368,544	1,564	239	1,803	242
Clearfield	8,218,194	184,572	180,547	293,510	8,876,823	9,416	1,330	10,746	251
Clinton	406,586	12,818	2,658	.....	422,062	335	78	413	281
Elk	882,394	34,449	20,740	.....	937,583	1,054	206	1,260	242
Fayette	7,364,658	509,020	654,509	25,661,661	34,249,848	20,562	7,883	28,445	295
Greene	609,390	14,160	19,726	101,584	744,860	550	157	707	304
Huntingdon	867,302	29,496	19,593	45,441	962,332	1,299	113	1,402	247
Indiana	10,614,057	79,036	179,001	150,696	11,022,780	9,253	2,073	11,326	255
Jefferson	4,518,522	70,405	166,242	1,009,356	5,764,525	4,461	1,019	5,480	270
Lawrence and Mercer	565,853	6,990	42,151	.....	614,994	796	160	956	262
Somerset	8,954,639	160,887	225,042	.....	9,340,568	8,129	1,389	9,518	243
Tioga	789,762	29,773	10,026	.....	829,561	1,326	216	1,536	229
Washington	16,353,087	269,177	305,927	1,191,162	18,119,353	16,782	2,352	19,134	229
Westmoreland	20,078,792	319,029	552,464	9,549,418	30,499,703	19,270	5,679	24,949	277
Small mines	.....	200,108	.....	.....	200,108	.....	.....	.....	.....
	123,181,649	4,212,186	3,375,483	39,526,106	170,295,424	139,186	29,026	168,212	259

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Value of bituminous coal produced in Pennsylvania in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Allegheny	$21,437,687	$920,527	$482,614	$1,576	$22,842,404	$1.34
Armstrong	6,176,298	163,388	187,898	.....	6,527,584	1.20
Beaver	53,975	85,739	975	.....	140,689	1.54
Bedford	991,671	20,255	15,853	180,537	1,208,316	1.67
Blair	577,071	2,838	12,291	47,245	639,445	1.47
Bradford and Lycoming	57,606	4,452	1,788	.....	63,846	1.64
Butler	1,505,093	68,394	37,789	.....	1,611,276	1.37
Cambria	23,852,633	1,696,436	365,331	2,087,036	28,001,436	1.43
Cameron and McKean	39,180	5,254	173	.....	44,607	1.55
Center	2,638,452	123,480	2,158	.....	2,764,090	1.52
Clarion	1,562,352	112,324	31,682	.....	1,706,358	1.25
Clearfield	11,327,583	255,292	204,289	430,660	12,217,824	1.38
Clinton	571,985	20,915	2,886	.....	595,786	1.41
Elk	1,106,387	43,215	23,458	.....	1,173,060	1.25
Fayette	9,366,645	725,213	783,355	31,275,874	42,151,087	1.23
Greene	933,485	11,034	22,460	126,980	1,093,959	1.47
Huntingdon	1,174,065	46,039	24,878	57,700	1,302,682	1.35
Indiana	12,424,240	112,030	187,806	143,770	12,867,846	1.17
Jefferson	5,008,240	73,391	165,274	1,089,459	6,936,364	1.20
Lawrence and Mercer	851,026	10,540	55,853	.....	917,419	1.49
Somerset	12,192,934	196,585	313,977	.....	12,703,496	1.36
Tioga	1,427,484	58,846	17,022	.....	1,503,352	1.81
Washington	22,391,997	387,061	357,557	1,073,530	24,210,145	1.34
Westmoreland	25,223,606	410,264	629,853	11,918,014	38,181,737	1.25
Small mines	.....	280,367	.....	.....	280,367	1.40
	163,491,695	5,833,879	3,927,220	48,432,381	221,685,175	1.30
Average value per ton	1.33	1.39	1.16	1.23	1.30	.....

Bituminous coal produced in Pennsylvania, 1912–1916, in net tons.

County.	1912	1913	1914	1915	1916	Increase or decrease, 1916.
Allegheny	18,867,365	20,117,823	16,808,302	17,417,815	17,007,431	− 410,384
Armstrong	4,104,989	5,321,622	4,579,389	5,159,882	5,430,188	+ 270,306
Beaver	247,465	248,585	101,909	87,891	91,553	+ 3,662
Bedford	731,477	850,792	634,319	635,791	721,587	+ 85,796
Blair	324,336	391,717	308,945	308,541	435,792	+ 127,251
Bradford and Lycoming	(a)	(b)	36,374	50,904	39,005	− 11,899
Butler	1,000,947	1,080,002	981,704	1,036,877	1,180,008	+ 143,131
Cambria	17,585,130	19,621,378	18,034,487	18,716,451	19,588,350	+ 871,899
Cameron and McKean	54,394	48,942	40,538	47,011	28,859	− 18,152
Center	1,291,374	1,497,271	1,264,075	1,430,749	1,819,007	+ 388,258
Clarion	1,199,322	1,427,848	1,341,392	1,291,119	1,368,544	+ 77,425
Clearfield	7,938,337	8,278,015	7,149,023	8,022,894	8,876,823	+ 853,929
Clinton	345,454	343,054	326,545	359,275	422,062	+ 62,787
Elk	1,146,496	1,201,065	963,338	1,045,554	937,583	− 107,971
Fayette	32,366,567	32,607,963	23,336,180	28,424,067	34,249,848	+ 5,825,781
Greene	35,839	316,752	290,497	546,008	744,860	+ 198,852
Huntingdon	834,914	935,774	851,128	1,010,750	962,332	− 48,418
Indiana	9,174,927	10,204,684	9,422,996	9,553,857	11,022,780	+ 1,468,923
Jefferson	5,416,536	5,801,864	5,080,623	4,895,409	5,764,525	+ 869,116
Lawrence	75,823	94,283	123,987	c131,746	c614,904	− c211,163
Mercer	846,228	777,601	716,995	c694,411	(c)	(c)
Somerset	9,888,144	9,928,776	10,238,763	10,343,369	9,340,568	− 1,002,801
Tioga	997,787	943,748	679,221	788,003	829,561	+ 41,558
Washington	16,645,127	18,309,317	15,495,674	15,898,719	18,119,353	+ 2,220,634
Westmoreland	30,589,549	33,258,702	28,995,427	29,802,561	30,499,703	+ 697,142
Small mines	a157,061	b173,039	172,863	165,483	200,108	+ 34,625
Total	161,865,488	173,781,217	147,983,294	157,955,137	170,295,424	+ 12,340,287
Total value	$169,370,497	$193,039,806	$159,006,296	$167,419,705	$221,685,175	+$54,265,470

a Small mines include Fulton and Lycoming counties; no production in Bradford County.
b Small mines include Lycoming County; no production in Bradford County.
c Lawrence County includes Mercer County in 1916.

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SOUTH DAKOTA.

A small quantity of lignite, amounting to 8,886 tons, was mined in the northwestern part of South Dakota in 1916, a decrease of 1,707 tons from the production in 1915. The average value per ton increased from $1.55 in 1915 to $2.03 in 1916.

All the lignite mined in South Dakota was used locally, about two-thirds of it in the immediate neighborhood of the mines and the remainder at places short distances away by rail.

Lignite produced in South Dakota in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Dewey and Harding	3,794	1,851	5,645	$7,476	$1.32	12	203
Meade	.....	400	400	1,485	3.71	4	93
Perkins	.....	4,548	4,548	7,423	1.63	19	138
	3,794	6,799	10,593	16,384	1.55	35	155

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Total quantity (net tons).	Number of employees			Average number of days worked.
				Underground.	Surface.	Total.	
Dewey, Harding, and Ziebach	891	1,435	2,326	8	2	10	10
Meade	.....	781	781	7	.....	7	139
Perkins	.....	5,779	5,779	11	10	21	133
	891	7,995	8,886	26	12	38	145

Value of lignite produced in South Dakota in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Total value.	Average value per ton.
Dewey, Harding, and Ziebach	$1,782	$2,887	$4,669	$2.01
Meade	.....	2,930	2,930	3.75
Perkins	.....	10,422	10,422	1.80
	1,782	16,239	18,021	2.03
Average value per ton	2.00	2.03	2.03	.....

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Lignite produced in South Dakota in 1913–1916, in net tons.

County.	1913	1914	1915	1916	Increase or decrease, 1916.
Dewey and Harding	1,040	5,142	5,645	a 2,326	— 3,319
Meade	575	625	400	781	+ 381
Perkins	8,925	6,083	4,548	5,779	+ 1,231
Total	10,540	11,850	10,593	8,886	— 1,707
Total value	$20,648	$20,456	$16,384	$18,021	+$1,637

a Includes Ziebach County.

TENNESSEE.

The output of coal in Tennessee in 1916 was 6,137,449 net tons, an increase compared with 1915 of 407,088 tons, or 7 per cent. The most important influence causing this increase was the demand for coke and coal by the iron and steel industry. All the industries in Tennessee and in neighboring States that depend on this coal were in full operation and used a maximum quantity of fuel. In the first half of the year market conditions and the demand for coal were about the same as in the last half of 1915. The car supply was ample, and the operators were able to furnish all the coal required. During this period there was a surplus of labor. In the last half and particularly in the last four months of the year the demand was in excess of the ability of the operators to supply, because of scarcity of labor and acute car shortage. It is reported that at the end of the year some of the operators were short 20 per cent of the desired number of men, and that in general the mines were able to ship but two-thirds of the coal called for in this period. Although the number of men employed in 1916 (9,211) was greater than in 1915 (8,948) the number was below the normal for recent years. A number of small mines that had been closed for several years were reopened, but no new large developments were undertaken because of the high cost of materials and machinery and of the recognized fact that the supply of labor and cars could not be increased to handle the output.

The value of the coal produced in 1916 was $7,522,445, an increase of $1,042,529, or 16 per cent.

Coal produced in Tennessee in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Anderson	489,695	5,737	15,090	.....	510,522	$537,246	$1.05	709	173
Campbell	1,597,076	19,387	47,245	.....	1,663,708	2,023,656	1.22	2,839	214
Claiborne	1,105,845	10,407	24,890	.....	1,141,142	1,171,513	1.03	1,167	221
Fentress	248,104	4,165	7,718	.....	259,987	261,266	1.00	387	278
Grundy	262,275	1,102	1,220	41,215	305,812	327,279	1.07	599	225
Marion	467,373	5,831	5,930	.....	479,134	653,608	1.36	915	216
Morgan	308,867	2,144	13,341	47,054	371,406	352,842	.95	567	227
Other counties a	696,357	16,905	52,126	227,869	993,257	1,143,789	1.15	1,765	233
Small mines	.....	5,393	.....	.....	5,393	8,717	1.62	.....	.....
	5,175,592	71,071	167,560	316,138	5,730,361	6,479,916	1.13	8,948	220

a Bledsoe, Fentress, Grundy, Hamilton, Overton, Rhea, Roane, Sequatchie, and White.

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Coal produced in Tennessee in 1915 and 1916—Continued.

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Anderson	492,275	6,984	12,564	.....	511,823	891	140	1,031	184
Campbell	1,256,098	26,683	54,732	171,399	1,508,912	2,135	424	2,559	218
Claiborne	1,501,533	17,470	31,287	.....	1,550,290	1,146	259	1,405	263
Fentress	294,801	1,760	4,120	.....	300,681	250	106	356	289
Grundy	279,074	2,297	3,273	50,501	335,145	470	43	513	307
Marion	516,918	4,399	8,789	31,382	561,488	741	166	907	268
Morgan	257,914	8,957	10,396	72,180	349,447	546	148	694	213
Scott	47,786	15,518	1,800	.....	65,104	122	12	134	284
Other counties [a]	620,334	9,882	47,132	271,872	949,220	1,360	252	1,612	.....
Small mines	.....	5,339	.....	.....	5,339	.....	.....	.....	.....
	5,266,733	99,289	174,093	597,334	6,137,449	7,661	1,550	9,211	239

[a] Bledsoe, Hamilton, Overton, Rhea, Roane, Sequatchie, and White.

Value of coal produced in Tennessee in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Anderson	$561,547	$8,717	$13,402	.....	$583,666	$1.14
Campbell	1,896,500	39,027	60,877	$130,411	2,126,815	1.41
Claiborne	1,597,005	18,330	29,377	.....	1,644,712	1.06
Fentress	311,068	1,862	4,532	.....	317,462	1.06
Grundy	293,731	2,447	3,438	51,048	350,664	1.05
Marion	724,709	6,794	12,564	47,073	791,140	1.41
Morgan	328,150	11,274	11,261	72,180	422,865	1.21
Scott	63,810	20,516	2,400	.....	86,726	1.33
Other counties [a]	782,552	15,447	39,248	351,633	1,188,880	1.25
Small mines	.....	9,515	.....	.....	9,515	1.78
	6,559,072	133,929	177,099	652,345	7,522,445	1.23
Average value per ton	1.25	1.35	1.02	1.09	1.23	.....

[a] Bledsoe, Hamilton, Overton, Rhea, Roane, Sequatchie, and White.

Coal produced in Tennessee, 1912–1916, in net tons.

County.	1912	1913	1914	1915	1916	Increase or decrease, 1916.
Anderson	542,467	659,345	579,619	510,522	511,823	+ 1,301
Bledsoe, Rhea, Roane, Sequatchie, and White	[a] 946,169	[a] 867,879	[b] 1,327,870	[c] 993,257	[d] 949,220	— 44,037
Campbell	1,763,918	1,779,338	1,675,521	1,663,708	1,508,912	— 154,796
Claiborne	1,251,650	1,456,468	1,371,052	1,141,142	1,550,290	+ 409,148
Fentress	(e)	(e)	(e)	259,987	300,681	+ 40,694
Grundy	290,589	319,736	(e)	305,812	335,145	+ 29,333
Hamilton	395,843	366,545	(e)	(e)	(e)	(e)
Marion	651,030	677,505	538,165	479,134	561,488	+ 82,354
Morgan	427,356	497,484	371,797	371,406	349,447	— 21,959
Overton	57,472	86,165	(e)	(e)	(e)	(e)
Scott	145,131	146,068	75,174	(e)	[f] 65,104	+ [f] 65,104
Small mines	1,703	3,636	4,060	5,393	5,339	— 54
Total	6,473,228	6,860,184	5,943,258	5,730,361	6,137,449	+ 407,088
Total value	$7,379,903	$7,839,721	$6,776,573	$6,479,916	$7,522,445	+$1,042,529

[a] Includes Cumberland and Fentress counties.
[b] Includes Fentress, Grundy, Hamilton, and Overton counties.
[c] Includes Hamilton, Overton, and Scott counties.
[d] Includes Hamilton and Overton counties.
[e] Included with Bledsoe and other counties.
[f] Included with Bledsoe and other counties in 1915.

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TEXAS.

The production of coal in Texas in 1916 was 1,987,503 net tons, or 101,405 tons less than in 1915. The production of lignite was 71,294 tons more than in 1915 and the production of bituminous coal decreased 172,699 tons. A strike that closed many of the bituminous mines throughout September was the principal cause of the decrease, as the demand for coal by railroads and industries was good and the supply of cars and labor was abundant during the whole year.

The number of men employed in the production of bituminous coal in Texas decreased from 3,680 in 1915 to 2,926 in 1916, and the average days worked decreased from 241 to 217. The lignite mines had more men and worked more days in 1916 than in 1915.

Coal produced in Texas in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Bituminous:								
Eastland, Erath, Maverick, Palo Pinto, Webb, Wise, Young	1,155,964	9,656	32,172	1,197,792	$2,715,393	$2.27	3,690	241
Lignite:								
Bastrop, Fayette, Henderson, Hopkins, Houston, Lee, Leon, Medina, Milam, Robertson, Titus, Wood	860,322	3,610	27,184	891,116	730,094	.82	1,407	219
	2,016,286	13,266	59,356	2,088,908	3,445,487	1.65	5,097	233

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Coal produced in Texas in 1915 and 1916—Continued.

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Bituminous:								
Erath, Maverick, Palo Pinto, Webb, Wise, Young	999,484	9,977	15,632	1,025,093	2,564	362	2,926	217
Lignite:								
Bastrop, Fayette, Henderson, Hopkins, Houston, Leon, Medina, Milam, Robertson, Titus, Wood	940,463	7,693	14,254	962,410	1,337	218	1,555	220
	1,939,947	17,670	29,886	1,987,503	3,901	580	4,481	218

Value of coal produced in Texas in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Bituminous:					
Erath, Maverick, Palo Pinto, Webb, Wise, Young	$2,251,715.00	$28,463.00	$24,104.00	$2,304,282.00	$2.25
Average value per ton	2.25	2.85	1.54	2.25	.....
Lignite:					
Bastrop, Fayette, Henderson, Hopkins, Houston, Leon, Medina, Milam, Robertson, Titus, Wood	771,147.00	6,348.00	10,886.00	788,381.00	.....
Average value per ton	.82	.83	.76	.82	.82
Average value per ton	3,022,862 1.55	34,811 1.97	34,990 1.17	3,092,663 1.56	1.56 .....

UTAH.

The production of coal in Utah in 1916 was 3,567,428 net tons, valued at $5,795,944, an increase, compared with 1915, of about 459,000 tons, or 15 per cent, in quantity and of $879,000, or 18 per cent, in value. The output in 1916 was the greatest on record for the State of Utah, and exceeds that of 1913, the previous record year,

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by more than 312,500 tons. The increase was largely in the commercial shipments from the mines in Carbon County, all other counties recording decrease. The consumption of Utah coal by the railroads increased, and the market on the Pacific was extended, largely by reason of the decrease in water-borne fuel from Australia and Japan and from the Atlantic coast of the United States. The activity of the smelters and metal mines was a large factor in causing the increase in the output of both coal and coke.

Except for short periods of car shortage, the transportation facilities were ample for the first 10 months of 1916. In November and December the car supply was reduced and production was somewhat curtailed. The supply of labor was normal in the early part of the year, but in the summer many men left the coal mines to work in the metal mines, where there is more working time and better wages, and many others were reported to have left to seek employment in munition factories and other industries in the Eastern States in the hope of getting better pay. The number of employees decreased from 3,564 in 1915 to 3,129 in 1916, but the average number of days worked increased from 208 to 228 in 1916. The average value of the coal per ton increased from $1.58 in 1915 to $1.62 in 1916.

Coal produced in Utah in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Carbon	1,896,257	28,324	92,087	654,387	2,671,055	$4,212,559	$1.58	2,842	200
Emery and Grand	375,544	6,552	7,984	.....	390,080	617,268	1.58	657	246
Summit and Uinta	30,999	7,445	4,233	.....	42,677	76,162	1.78	65	175
Small mines	.....	4,903	.....	.....	4,903	10,927	2.23	.....	.....
	2,302,800	47,224	104,304	654,387	3,108,715	4,916,916	1.58	3,564	208

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Carbon	2,326,864	50,705	67,822	736,853	3,182,244	2,098	648	2,746	229
Emery and Grand.	328,259	5,059	6,613	.....	339,931	221	71	292	214
Summit and Uinta	31,757	6,100	4,000	.....	41,857	78	13	91	254
Small mines	.....	3,396	.....	.....	3,396	.....	.....	.....	.....
	2,686,880	65,260	78,435	736,853	3,567,428	2,397	732	3,129	228

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Value of coal produced in Utah in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Carbon	a$4,931,616	$75,905	$31,917	(a)	$5,039,438	$1.58
Emery and Grand	644,141	9,338	3,714	0	657,193	1.93
Summit and Uinta	74,785	13,750	2,000	0	90,535	2.16
Small mines	0	8,778	0	0	8,778	2.59
	5,650,542	107,771	37,631	(a)	5,796,944	1.62
Average value per ton	1.65	1.65	.48	(a)	1.62	.....

a Value of coal made into coke at the mines included in loaded at mines for shipment.

Coal produced in Utah, 1912–1916, in net tons.

County.	1912	1913	1914	1915	1916	Increase or decrease, 1916.
Carbon	2,684,731	2,830,102	2,669,511	2,671,055	3,182,244	+ 511,189
Emery	a212,818	b314,915	a257,768	a390,080	a339,931	− 50,149
Summit, Uinta	114,657	108,027	73,025	42,677	41,857	− 820
Small mines	3,943	1,784	2,732	4,903	3,396	− 1,507
Total	3,016,149	3,254,828	3,103,036	3,108,715	3,567,428	+ 458,713
Total value	$5,046,451	$5,384,127	$4,935,454	$4,916,916	$5,795,944	+$879,028

a Includes Grand County. b Includes Grand and Sevier counties.

VIRGINIA.

The output of coal in Virginia in 1916 was 9,707,474 net tons, valued at $10,261,424, an increase compared with 1915 of 1,584,878 tons, or 19.5 per cent, in quantity and of $2,298,490, or 29 per cent, in value. The quantity of coal made into coke increased more than 967,000 tons, and shipments of coal increased 565,406 tons. The demand for coal and coke from the Virginia fields was strong throughout the year, and it is reported that consumers called for the maximum on all contracts. In the last six months of the year the demand was considerably in excess of the supply. Although more abundant than in 1915, labor was in short supply at nearly all the mines during the whole year, and the supply of cars was inadequate from June to the end of the year.

The only notable extension of markets for coal from Virginia is the increasing demand for bunker coal at Charleston, S. C., where late in 1915 a new modern coal pier was put into operation by the Southern Railway. It is reported that shipowners are recognizing the fact that satisfactory bunker coal can be obtained quickly at this port, and vessels trading between Gulf ports and South America and Europe (particularly Mediterranean ports) are now calling there for bunker coal.

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Coal produced in Virginia in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Lee	719,927	6,323	16,061	.....	742,311	$778,861	$1.05	953	248
Russell	1,456,403	14,804	22,214	.....	1,493,421	1,351,460	.90	1,526	243
Tazewell	1,480,816	23,932	20,641	121,692	1,647,081	1,844,353	1.12	1,427	198
Wise	3,251,443	28,023	72,183	834,660	4,186,309	3,874,099	.93	4,864	240
Other counties [a] and small mines	39,646	9,128	4,700	.....	53,474	114,123	2.13	189	251
	6,948,235	82,210	135,799	956,352	8,122,596	7,962,934	.98	8,959	235

1916.

County.	Loaded at mine for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Lee	813,543	4,638	9,819	.....	828,000	805	160	965	255
Russell	1,907,651	41,501	884	.....	1,950,036	680	998	1,678	290
Tazewell	1,418,706	23,315	24,514	121,509	1,588,044	1,286	287	1,573	234
Wise	3,324,897	48,176	53,654	1,802,218	5,228,945	4,397	894	5,291	283
Other counties [a] and small mines	48,844	39,100	24,505	.....	112,449	191	79	270	227
	7,513,641	156,730	113,376	1,923,727	9,707,474	7,359	2,418	9,777	272

[a] Montgomery and Pulaski.

Value of coal produced in Virginia in 1916.

County.	Loaded at mines for shipment	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Lee	$926,672	$6,720	$9,230	.....	$942,622	$1.14
Russell	1,870,773	40,853	1,017	.....	1,912,643	98
Tazewell	1,987,484	30,990	32,681	$103,885	2,155,040	1.36
Wise	3,442,866	52,454	53,644	1,511,478	5,060,442	97
Other counties and small mines [a]	120,873	44,269	25,535	.....	190,677	1.70
	8,348,668	175,286	122,107	1,615,363	10,261,424	1.06
Average value per ton	1.11	1.12	1.06	.84	1.06	.....

[a] Montgomery and Pulaski.

Coal produced in Virginia, 1912–1916, in net tons.

County.	1912	1913	1914	1915	1916	Increase or decrease, 1916.
Lee	751,276	763,315	732,935	742,311	828,000	+ 85,689
Montgomery and Pulaski	(a)	(a)	45,151	51,141	109,543	+ 58,402
Russell	[b] 1,292,365	[b] 1,512,356	1,226,114	1,493,421	1,950,036	+ 456,615
Tazewell	1,302,043	1,447,351	1,323,530	1,647,081	1,588,044	— 59,037
Wise	4,500,174	5,103,559	4,620,702	4,186,309	5,228,945	+1,042,636
Small mines	780	1,487	1,103	2,333	2,906	+ 573
Total	7,846,638	8,828,068	7,959,535	8,122,596	9,707,474	+1,584,878
Total value	$7,518,576	$8,952,653	$8,032,448	$7,962,934	$10,261,424	+$2,298,490

[a] Included with Russell County. [b] Includes Henrico, Montgomery, and Pulaski.

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WASHINGTON.

The production of coal in Washington in 1916 was 3,038,588 net tons, valued at $6,907,428, an increase compared with 1915 of 609,493 tons, or 25 per cent, in quantity and of $1,631,129, or 31 per cent, in value. The increase is attributed to the prosperous condition of the lumber and logging companies, manufacturing plants, and the railroads, and to the increased price of California fuel oil. The demand for bunker coal was better than in recent years, for although there were fewer vessels in service, those that formerly bunkered for the round trip with Japanese and Australian coal now use the extra space for cargo and take coal for the return trip on this side. The shortage of labor and higher costs of mining in British Columbia because of the war and the decrease of shipments from Utah and Wyoming mines into eastern Washington because of car shortage also gave the operators in Washington a larger opportunity to market their coal.

The supply of labor is reported to have been adequate throughout the year, and there was no shortage of cars for shipments to points in Washington, although cars were not available for shipments to other markets.

Coal produced in Washington in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
King	762,081	34,014	54,000	.....	850,095	$1,623,592	$1.91	1,834	157
Kittitas	831,101	13,955	34,336	.....	879,392	2,092,689	2.38	1,530	126
Lewis	64,225	11,777	4,886	.....	80,888	136,959	1.69	177	127
Pierce	315,867	3,783	28,693	149,290	497,633	1,232,076	2.48	1,193	248
Thurston and Whatcom	115,777	1,178	4,132	.....	121,087	190,983	1.58	116	166
	2,089,051	64,707	126,047	149,290	2,429,095	5,276,299	2.17	4,850	169

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
King	821,718	30,280	58,111	.....	910,109	1,370	480	1,850	191
Kittitas	1,252,871	19,976	45,182	.....	1,318,029	1,309	199	1,508	224
Lewis	88,193	16,643	5,317	.....	110,153	137	33	170	200
Pierce	371,433	8,155	12,130	136,863	528,581	848	278	1,126	256
Thurston and Whatcom	166,816	900	4,000	.....	171,716	100	43	143	185
	2,701,031	75,954	124,740	136,863	3,038,588	3,764	1,033	4,797	217

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Value of coal produced in Washington in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
King	$1,822,310	$69,396	$78,351	.....	$1,970,559	$2.17
Kittitas	3,058,690	43,737	67,548	.....	3,169,975	2.41
Lewis	172,495	32,583	4,558	.....	209,636	1.90
Pierce	827,994	19,169	24,249	$402,858	1,274,280	2.41
Thurston and Whatcom	276,328	1,650	5,000	.....	282,978	1.65
	6,158,317	166,537	179,706	402,858	6,907,428	2.27
Average value per ton	2.28	2.19	1.44	2.94	2.27	.....

Coal produced in Washington, 1912–1916, in net tons.

County.	1912	1913	1914	1915	1916	Increase or decrease, 1916.
King	1,063,110	1,373,699	1,041,780	850,095	910,109	+ 60,014
Kittitas	1,237,427	1,334,155	1,242,800	879,392	1,318,029	+ 438,637
Lewis	128,377	151,446	103,860	80,888	110,153	+ 29,265
Pierce	788,293	856,425	556,519	497,533	528,581	+ 30,948
Thurston and Whatcom	143,725	162,166	119,861	121,087	171,716	+ 50,629
Total	3,360,932	3,877,891	3,064,820	2,429,095	3,038,588	+ 609,493
Total value	$8,042,871	$9,243,137	$6,751,511	$5,276,299	$6,907,428	+$1,631,129

WEST VIRGINIA.

The production of coal in West Virginia in 1916 was 86,460,127 net tons, valued at $102,366,092, an increase of 9,276,058 tons, or 12 per cent, in quantity and of $27,804,743, or 37 per cent, in value. Practically every district shared in the increase, although some of the large operators did not reach their 1915 record. The only large producing counties that recorded noteworthy decreases were Marion and Tucker. Notwithstanding a disastrous flood in August, which decreased the possible output to a large extent, the Cabin Creek district in Kanawha County recorded an increase of more than 700,000 tons. The largest increase was in the Pocahontas and New River fields—McDowell County having gained more than 3,000,000 tons, Fayette more than 815,000 tons, Raleigh about 1,106,000 tons, and Wyoming nearly 456,000 tons—and in Logan County, which increased from 7,918,963 tons to 9,412,402 tons, or 1,493,439 tons.

Coal from West Virginia for export, for railroad fuel, and for industrial purposes in the inland markets was in strong demand throughout the year. To meet this demand the mines worked more days than in 1915, the average for the State increasing from 208 days in 1915 to 237 in 1916. Logan, McDowell, Mercer, Mingo, and Wyoming counties, among the more important producers, had a greater supply of labor than in 1915; in Fayette, Harrison, Kanawha, Marion, Randolph, and Taylor counties the mines operated with fewer men than in 1915, but these men worked more days in the year.

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The demand for coal was strongest in the last half of the year, and when the attempt was made to speed up production to meet this demand it was found impossible in many districts to obtain sufficient men and a labor shortage was the factor limiting production, or if sufficient labor was available, the railroads could not supply sufficient cars and car supply was the limiting factor. Inasmuch as the number of men employed in the State in 1916 was more than 2,000, or 3 per cent greater than in 1915, and the average number of days worked increased from 208 to 237, or 14 per cent, and the total production increased 12 per cent, it will be seen that labor and in particular car shortages were reported only because they imposed limits in production below the demand for coal.

Coal produced in West Virginia in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Barbour	1,256,903	5,716	21,748	35,702	1,320,069	$1,009,586	$0.76	1,126	216
Boone	644,967	9,592	7,339	.....	661,898	616,705	.93	808	159
Brooke	600,080	10,703	4,663	.....	615,446	650,834	1.06	864	203
Clay	573,515	3,886	6,804	.....	584,205	514,751	.88	384	261
Fayette	9,628,482	146,713	159,871	247,892	10,182,958	10,632,401	1.04	12,159	226
Gilmer	142,220	2,461	3,444	.....	148,125	124,589	.84	125	208
Grant	211,027	678	4,230	.....	215,935	185,988	.86	220	255
Hancock	.....	4,934	.....	.....	4,934	6,615	1.34	8	158
Harrison	5,021,284	17,359	36,786	36,732	5,112,161	4,182,162	.82	4,383	189
Kanawha	5,184,964	65,272	54,988	.....	5,305,224	4,986,328	.94	7,096	161
Lincoln	37,008	7,448	500	.....	44,956	42,627	.95	165	87
Logan	7,786,860	60,313	71,790	.....	7,918,963	6,485,664	.82	6,372	185
McDowell	16,029,494	171,576	262,361	948,008	17,411,439	18,341,530	1.05	14,979	212
Marion	6,357,384	22,366	195,503	114,460	6,689,713	5,807,544	.87	5,488	235
Marshall	798,996	164,939	27,025	.....	990,960	1,018,931	1.03	1,122	251
Mason	105,525	15,119	2,135	.....	122,779	126,942	1.03	196	246
Mercer	3,229,190	32,764	36,624	190,471	3,489,049	3,724,704	1.07	3,181	223
Mineral	652,808	2,098	5,344	.....	660,250	609,378	.92	888	215
Mingo	2,781,277	28,337	62,125	.....	2,871,739	2,727,377	.95	3,276	200
Monongalia	290,920	11,731	1,469	96,102	400,222	335,193	.84	392	181
Ohio	513,350	62,188	1,329	.....	576,867	581,898	1.01	500	254
Preston	1,034,283	19,746	35,328	150,257	1,239,614	999,434	.81	1,258	225
Putnam	533,683	5,442	8,544	.....	547,669	630,611	1.15	1,041	224
Raleigh	5,722,777	94,441	66,267	.....	5,883,485	6,314,558	1.07	5,505	215
Randolph	312,753	7,361	10,465	121,117	451,696	366,968	.81	370	160
Taylor	1,022,612	4,383	14,065	27,534	1,068,594	788,826	.74	1,121	175
Tucker	1,587,732	15,172	30,457	18,206	1,651,567	1,756,940	1.06	1,639	255
Upshur	85,015	2,763	1,802	8,567	98,147	67,849	.69	97	203
Wyoming	240,476	3,231	28	.....	243,735	271,165	1.11	456	158
Other counties[a]	570,656	6,393	8,144	231	585,424	545,136	.93	663	226
Small mines	.....	86,246	.....	.....	86,246	108,115	1.25	.....	.....
	72,956,241	1,091,371	1,141,178	1,995,279	77,184,069	74,561,349	.97	75,882	208

[a] Braxton, Greenbrier, Lewis, Nicholas, Wayne, and Webster.

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Coal produced in West Virginia in 1915 and 1916—Continued.

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Made into coke at mines (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
						Underground.	Surface.	Total.	
Barbour	1,264,692	16,919	22,507	62,991	1,367,109	924	151	1,075	247
Boone	743,943	6,750	9,043	.....	759,736	724	178	902	183
Braxton	293,051	31,012	5,465	.....	329,528	205	45	250	224
Brooke	699,585	12,114	8,553	.....	720,252	718	114	832	268
Clay	466,147	5,783	8,782	.....	480,712	363	92	455	233
Fayette	10,155,529	182,546	131,594	528,357	10,998,026	9,702	2,088	11,790	245
Gilmer	117,374	4,398	3,709	.....	125,481	117	24	141	201
Grant	197,278	596	5,185	.....	203,059	166	18	184	244
Hancock	.....	4,763	.....	.....	4,763	6	1	7	180
Harrison	4,953,619	135,074	34,417	63,864	5,186,974	3,517	612	4,129	231
Kanawha	5,876,599	97,376	53,167	.....	6,027,142	5,353	999	6,352	214
Lincoln	179,692	1,814	1,760	.....	183,266	203	65	268	183
Logan	9,229,779	129,172	53,451	.....	9,412,402	5,653	1,344	6,997	200
McDowell	17,799,948	223,561	297,067	2,164,529	20,485,125	14,049	2,965	17,014	250
Marion	5,635,387	122,480	205,873	133,329	6,097,059	3,924	880	4,804	239
Marshall	913,338	273,652	22,614	.....	1,209,604	855	126	981	284
Mason	63,196	54,727	1,714	.....	119,637	207	37	244	165
Mercer	3,344,308	33,108	35,307	280,448	3,693,171	2,684	583	3,267	247
Mineral	683,966	2,847	5,437	.....	692,250	730	176	906	217
Mingo	3,366,349	33,019	74,769	.....	3,474,137	2,841	652	3,493	246
Monongalia	480,114	12,017	2,061	96,147	590,339	405	103	508	219
Ohio	529,374	107,009	1,570	.....	637,953	471	61	532	225
Preston	1,025,097	20,265	36,248	197,472	1,279,082	1,090	194	1,284	237
Putnam	588,642	2,395	13,311	.....	604,348	881	186	1,067	251
Raleigh	6,826,540	89,510	73,722	.....	6,989,772	4,941	1,017	5,958	240
Randolph	519,843	28,713	10,920	172,821	732,297	444	110	554	209
Taylor	1,419,017	4,889	14,684	27,534	1,466,124	1,012	186	1,198	260
Tucker	1,225,569	16,147	29,320	19,699	1,290,735	1,308	188	1,496	245
Upshur	141,990	2,880	2,004	12,223	159,187	87	39	126	243
Webster	16,949	4,000	250	.....	21,199	16	2	18	246
Wyoming	694,680	4,262	739	.....	699,681	688	139	827	264
Other counties [b]	309,086	15,132	5,852	.....	330,070	334	74	408	272
Small mines	.....	89,897	.....	.....	89,897	.....	.....	.....	.....
	79,760,681	1,768,827	1,171,205	3,759,414	86,460,127	64,618	13,449	78,067	237

[b] Greenbrier, Lewis, Nicholas, and Wayne.

Value of coal produced in West Virginia in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Barbour	$1,240,189	$15,706	$23,646	$68,745	$1,348,286	$0.99
Boone	927,835	7,623	10,541	.....	945,999	1.25
Braxton	331,713	27,740	4,312	.....	363,765	1.10
Brooke	891,916	15,095	7,632	.....	914,643	1.27
Clay	535,779	5,540	8,137	.....	549,456	1.14
Fayette	12,625,992	204,531	135,316	588,951	13,554,490	1.23
Gilmer	132,970	5,712	3,331	.....	142,013	1.13
Grant	204,119	624	11,136	.....	215,879	1.06
Hancock	.....	6,389	.....	.....	6,389	1.34
Harrison	5,704,611	152,484	36,635	77,478	5,971,208	1.15
Kanawha	6,985,169	105,463	59,868	.....	7,150,500	1.19
Lincoln	268,628	2,690	2,415	.....	273,733	1.49
Logan	10,177,795	125,009	49,888	.....	10,352,692	1.10
McDowell	22,158,070	254,714	291,778	1,663,791	24,368,353	1.19
Marion	6,624,185	141,627	183,516	150,324	7,099,652	1.16
Marshall	1,046,582	402,069	22,614	.....	1,471,265	1.22
Mason	90,720	69,225	2,268	.....	162,213	1.36
Mercer	4,104,193	37,753	39,047	201,963	4,382,956	1.19
Mineral	931,156	3,477	6,555	.....	941,188	1.36
Mingo	3,914,000	27,990	64,538	.....	4,006,528	1.15
Monongalia	634,266	12,880	2,204	95,506	744,856	1.26
Ohio	633,760	139,182	1,705	.....	774,647	1.21

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Value of coal produced in West Virginia in 1916—Continued.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke at mines.	Total value.	Average value per ton.
Preston	$1,184,306	$25,978	$45,977	$271,597	$1,527,858	$1.19
Putnam	772,888	2,874	12,853	.....	788,615	1.30
Raleigh	8,616,001	108,612	77,036	.....	8,801,649	1.26
Randolph	532,669	34,992	9,335	146,589	723,585	0.99
Taylor	1,470,844	5,776	12,822	34,968	1,524,410	1.04
Tucker	1,472,744	18,238	35,338	23,216	1,549,536	1.20
Upshur	173,721	3,298	2,871	11,612	191,502	1.20
Webster	26,892	6,000	500	.....	33,392	1.58
Wyoming	881,274	4,224	900	.....	886,398	1.27
Other counties [a]	451,008	14,952	5,674	.....	471,634	1.43
Small mines	.....	126,802	.....	.....	126,802	1.41
	95,745,695	2,115,269	1,170,388	3,334,740	102,366,092	1.18
Average value per ton	1.20	1.20	1.00	0.89	1.18	.....

[a] Greenbrier, Lewis, Nicholas, and Wayne.

Coal produced in West Virginia, 1912–1916, in net tons.

County.	1912	1913	1914	1915	1916	Increase or decrease, 1916.
Barbour	1,163,361	1,415,301	1,331,948	1,320,069	1,367,109	+ 47,040
Boone	379,976	445,856	592,558	661,898	759,736	+ 97,838
Braxton	234,988	282,517	306,608	(a)	329,528	+ 329,528
Brooke	494,471	(a)	554,870	615,446	720,252	+ 104,806
Clay	212,125	371,296	563,561	584,205	480,712	− 103,493
Fayette	9,636,230	9,944,027	9,038,738	10,182,958	10,998,026	+ 815,068
Gilmer	76,735	93,337	114,876	148,125	125,481	− 22,644
Grant	(a)	223,045	179,642	215,935	203,059	− 12,876
Greenbrier, Hancock, Lewis, Nicholas, Wayne, and Webster	[b] 522,706	[c] 790,285	[d] 265,664	[e] 590,358	[f] 330,070	− 234,326
Hancock	.....	.....	.....	.....	4,763	+ (a)
Harrison	5,171,772	5,584,437	5,291,683	5,112,161	5,186,974	+ 74,813
Kanawha	5,113,557	5,372,953	5,989,055	5,305,224	6,027,142	+ 721,918
Lincoln	(a)	(a)	(a)	44,956	183,266	+ 138,310
Logan	4,196,744	4,753,516	6,618,951	7,918,963	9,412,402	+ 1,493,439
McDowell	15,809,289	16,498,447	14,588,564	17,411,439	20,485,125	+ 3,073,686
Marion	5,793,124	6,052,872	6,731,542	6,689,713	6,097,069	− 592,644
Marshall	798,028	866,049	1,153,126	990,960	1,209,604	+ 218,644
Mason	131,303	148,091	121,911	122,779	119,637	− 3,142
Mercer	3,109,571	3,317,012	2,961,141	3,489,049	3,693,171	+ 204,122
Mineral	726,316	851,475	633,406	660,250	692,250	+ 32,000
Mingo	2,597,479	2,690,418	2,839,014	2,871,739	3,474,137	+ 602,398
Monongalia	409,579	394,640	414,821	400,222	590,339	+ 190,117
Ohio	412,494	412,640	570,347	576,987	637,953	+ 61,086
Preston	1,167,758	1,331,907	1,240,650	1,239,614	1,279,082	+ 39,468
Putnam	612,066	622,776	544,859	547,669	604,348	+ 56,679
Raleigh	5,134,217	5,697,581	5,454,059	5,883,485	6,989,772	+ 1,106,287
Randolph	616,410	593,525	520,360	451,096	732,297	+ 280,601
Taylor	871,852	1,046,770	1,308,704	1,068,594	1,466,124	+ 397,530
Tucker	1,270,578	1,293,489	1,504,215	1,651,567	1,290,735	− 360,832
Upshur	59,330	96,822	119,757	98,147	159,187	+ 61,040
Webster	.....	.....	.....	.....	21,199	+ (a)
Wyoming	.....	(a)	75,058	243,735	699,681	+ 455,946
Small mines	64,628	62,652	77,938	86,246	89,897	+ 3,651
Total	66,786,687	71,254,136	71,707,626	77,184,069	86,460,127	+ 9,276,058
Total value	$62,792,234	$71,822,804	$71,391,408	$74,561,349	$102,366,092	+ $27,804,743

[a] Included with Greenbrier and other counties.
[b] Includes Grant and Lincoln counties.
[c] Includes Brooke, Lincoln, and Wyoming counties.
[d] Includes Lincoln County.
[e] Includes Braxton County.
[f] Greenbrier, Lewis, Nicholas, and Wayne counties only in 1916.

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WYOMING.

The production of coal in Wyoming in 1916 was 7,910,647 net tons, an increase compared with 1915 of 1,356,619 tons, or 21 per cent. The output in 1916 established a new high record for the State. The increase was due mainly to greater consumption of coal by railroads, the transcontinental movement of freight being the greatest on record. The car supply was nearly equal to requirements, except in September and October. The supply of labor was short in November and December, but was in general as good as in 1915. The average number of days worked increased from 201 in 1915 to 248 in 1916.

The value of the coal produced in 1916 was $12,239,707, an increase of $2,683,903, or 28 per cent. The average value per ton in 1916 was $1.55 against $1.46 in 1915.

Coal produced in Wyoming in 1915 and 1916.

1915.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Total value.	Average value per ton.	Number of employees.	Average number of days worked.
Carbon and Uinta	626,507	11,903	31,242	669,652	$993,043	$1.48	611	229
Converse, Johnson, and Weston	328,686	6,755	19,633	355,074	669,380	1.88	469	175
Fremont, Hot Springs, and Park	469,918	5,603	22,080	497,601	833,706	1.68	543	205
Lincoln	1,316,653	10,352	89,296	1,416,301	2,145,828	1.52	1,572	233
Sheridan	926,262	12,617	37,744	978,623	1,103,605	1.13	1,157	140
Sweetwater	2,555,185	20,122	56,937	2,632,244	3,799,437	1.44	2,891	203
Small mines	.....	4,533	.....	4,533	10,805	2.38	.....	.....
	6,225,211	71,885	256,932	6,554,028	9,555,804	1.46	7,244	201

1916.

County.	Loaded at mines for shipment (net tons).	Sold to local trade and used by employees (net tons).	Used at mines for steam and heat (net tons).	Total quantity (net tons).	Number of employees.			Average number of days worked.
					Underground.	Surface.	Total.	
Carbon and Uinta	750,255	13,803	26,755	790,813	532	131	663	282
Fremont, Hot Springs, and Park	588,925	19,874	35,636	644,435	493	110	603	316
Johnson and Weston	338,179	8,778	19,787	366,744	359	58	417	255
Lincoln	1,783,918	12,163	92,628	1,888,709	1,504	246	1,750	273
Sheridan	1,274,329	14,883	24,851	1,314,063	928	256	1,184	196
Sweetwater	2,812,100	21,891	67,229	2,901,220	2,225	413	2,638	253
Small mines	.....	4,663	.....	4,663	.....	.....	.....	.....
	7,547,706	96,055	266,886	7,910,647	6,041	1,214	7,255	248

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Value of coal produced in Wyoming in 1916.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total value.	Average value per ton.
Carbon and Uinta	$1,114,449	$18,604	$28,371	$1,161,424	$1.47
Fremont, Hot Springs, and Park	1,080,875	33,624	18,318	1,132,817	1.76
Johnson and Weston	662,191	14,933	19,787	696,911	1.90
Lincoln	2,690,067	20,817	65,870	2,776,754	1.47
Sheridan	1,926,209	22,900	9,072	1,958,181	1.49
Sweetwater	4,399,188	32,779	72,896	4,504,863	1.55
Small mines	.....	8,757	.....	8,757	1.88
	11,872,979	152,414	214,314	12,239,707	1.55
Average value per ton	1.57	1.59	0.80	1.55	.....

Coal produced in Wyoming, 1913–1916, in net tons.

County.	1913	1914	1915	1916	Increase or decrease, 1916.
Carbon and Uinta	682,495	684,618	669,652	790,813	+ 121,161
Converse, Johnson, and Weston	371,397	364,540	355,074	[a] 366,744	+ 11,670
Fremont, Hot Springs, and Park	420,819	429,539	497,601	644,435	+ 146,834
Lincoln	1,871,461	1,482,421	1,416,301	1,888,709	+ 472,408
Sheridan	1,211,167	1,001,411	978,623	1,314,063	+ 335,440
Sweetwater	2,832,475	2,509,371	2,632,244	2,901,220	+ 268,976
Small mines	[b] 3,252	3,393	4,533	4,663	+ 130
Total	7,393,066	6,475,293	6,554,028	7,910,647	+ 1,356,619
Total value	$11,510,045	$10,033,747	$9,555,804	$12,239,707	+$2,683,903

[a] Johnson and Weston counties only.

[b] Includes Crook County.

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STONE.

By G. F. Loughlin.[1]

INTRODUCTION.

The tables in this report were completed about a month later than usual, owing to shortage of clerical help. Since their completion the writer has had to give considerable time to special duties directly or indirectly due to the war, and the writing of the report has therefore been much delayed. This delay has been offset so far as possible, however, by the issue of advance statements containing the more important figures of production in 1916. The first of these statements, on Indiana limestone, was released to the public on May 30, 1917; the second, on production of limestone for furnace flux, on August 27; the third, on production of limestone in Missouri and Kentucky, on August 28. Other statements followed in September, October, and November. Similar press statements of production of stone in 1917 will be issued as soon as the figures for any important district or kind of stone are complete. There is no reason, if reports from producers are promptly made, why such advance statements of production for important stone-producing districts can not be issued early in each year.

The figures in this as in previous reports represent stone produced and sold or used by the quarrymen. They include only such manufactured product as is put on the market by the quarrymen themselves and for which no record of equivalent quantity and value of rough stone is available. These manufactured products include some building and monumental stone, crushed stone, flagstone, curbstone, and paving blocks. The value given to the manufactured product is the price received by the producer free on board at point of shipment. If rough stone is sold to local trade, the value given is, so far as possible, that of the stone at the quarry, but occasionally, if the producer also delivers the stone, cost of delivery is included. In a few places, where the producer has a long haul to market or to a railroad shipping point, this cost materially increases the selling price.

Where possible the quantity as well as the value of stone sold is given, but owing to the several different units of quantity reported by different producers and to the impossibility of converting them accurately to terms of one unit, no figures for quantity can be given in the more general tables. A brief statement of the different units of quantity reported by producers was given in the report for 1915.[1] Some producers fail to report any figures for quantity, and a few even say it is impossible for them to do so.

[1] The statistical tables in this report have been prepared by Miss A. T. Coons, of the United States Geological Survey; those on imports have been compiled by J. A. Dorsey, also of the Survey, from records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

[1] U. S. Geol. Survey Mineral Resources, 1915, pt. 2, pp. 762-763, 1916.

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For simplicity of treatment, the kinds of stone covered by the statistics of this report, as of former reports, are classified as granite, basalt and related rocks (trap rock), marble, limestone, and sandstone. Small quantities of other kinds of stone less commonly used have been included in one or another of these groups, as specified in the following paragraphs. As in recent years these other kinds of stone have been increasing both in quantity and variety, the present method of classification has become less and less satisfactory, and it is hoped that in the report for 1917 they will be segregated under the heading "miscellaneous."

"Granite" includes true granite and also such allied rocks as monzonite, syenite, gneiss, and certain other igneous and metamorphic rocks which are quarried by too few producers to permit their production to be shown separately. The varieties of igneous rocks thus occasionally included under "granite" are mostly of the light volcanic type, such as tuff, rhyolite, trachyte, and andesite, but from time to time small quantities of dark igneous rocks, such as diorite and gabbro, used for monumental and building work are necessarily included with granite.

"Basalt and related rocks," included under the term "trap rock" until 1914, comprise, besides typical basalt and diabase, fine-grained diorite, gabbro, and other basic rocks which are less common in occurrence but are similar in chemical and physical properties and are used largely as crushed stone.

"Marble" includes a small quantity of serpentine quarried and sold as marble in California, Georgia, Maryland, Massachusetts, Pennsylvania, and Vermont, and also a small quantity of the so-called onyx marble or travertine obtained from caves and other deposits in Kentucky and other States.

"Limestone" represented in the tables of this report does not include limestone burned into lime, bituminous limestone, nor limestone entering into the manufacture of Portland cement. Separate reports are made on the lime and cement industries.

"Sandstone" includes the quartzites of South Dakota, Minnesota, and Wisconsin, and the fine-grained sandstones of New York and Pennsylvania, known to the trade as "bluestone." As "bluestone" is the product of a distinct local industry, its production is shown separately from that of the other sandstones. "Bluestone" is also quarried in New Jersey and West Virginia, but this product is small and is not separated from sandstone. In Kentucky most of the sandstone quarried and sold is known locally as freestone. The figures given for sandstone do not include the value of the grindstones, whetstones, and pulpstones made from sandstones quarried in Arkansas, Indiana, Michigan, Ohio, and West Virginia. These products are included in the report on abrasives. Sandstone crushed into sand and used in the manufacture of glass and as molding sand is considered in the report on sand and gravel.

MARKETED PRODUCTION.

PRODUCTION BY KINDS OF STONE.

General statistics.—In 1916 the total value of stone, like that of other important mineral products sold, increased considerably compared to the output in 1915; but a glance at the accompanying

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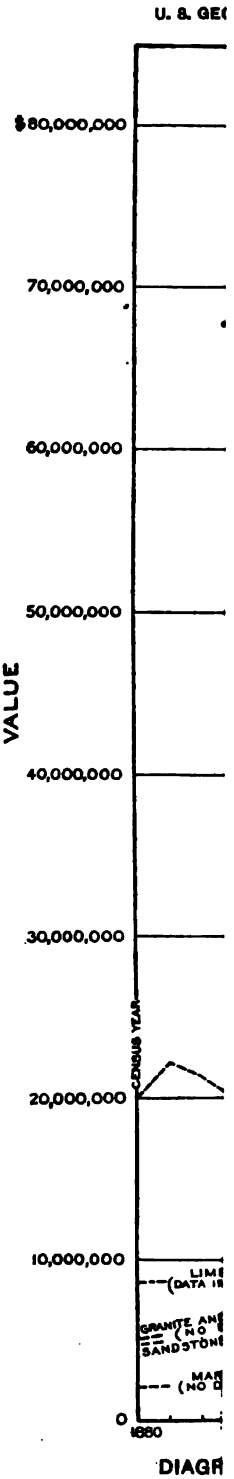

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diagram (Pl. IV) will show that this increase was due almost entirely to sales of limestone, which more than offset decrease in granite, basalt, and sandstone. Although the generally prosperous year 1916 was one of very great building and manufacturing activity, the great majority of buildings constructed, including factories and dwellings, were not the kind that call for building stone. Crushed stone for concrete and especially furnace flux, on the other hand, were in great demand, and limestone sold to various chemical manufactories increased considerably. This year of prosperity to individuals engaged in many industries was also characterized by a marked increase in sales of monumental stone, the bulk of which depends on individual resources.

The total value of stone sold in the United States in 1916 was $79,041,699, an increase over 1915 of $4,446,347, or nearly 6 per cent. The value in 1916, as shown in the accompanying table and Plate IV, was greater than in any other year except 1913, the record year.

Value of the different kinds of stone produced and sold in the United States, 1880–1916.[a]

Year.	Granite.	Basalt and related rocks (trap rock).[b]	Sandstone.	Marble.	Limestone.	Total.
1880	$5,188,998	.....	$4,780,391	$2,041,225	$8,615,456	$20,626,070
1881	.....	.....	.....	.....	[c] 4,100,000	22,556,162
1882	.....	.....	.....	.....	[c] 2,310,000	21,556,500
1883	.....	.....	.....	.....	[c] 1,907,136	20,008,886
1884	.....	.....	[d] 2,500,000	.....	[c] 1,700,965	18,849,100
1885	.....	.....	[d] 2,000,000	.....	[c] 1,678,478	19,030,011
1886	.....	.....	.....	2,400,000	8,930,297	20,219,927
1887	7,440,000	.....	6,500,000	3,100,000	9,476,200	26,516,200
1888	8,000,000	.....	6,750,000	3,000,000	8,969,000	26,719,000
1889	14,464,095	.....	12,505,663	3,488,170	12,467,852	42,925,780
1890	.....	.....	.....	.....	.....	49,760,811
1891	13,867,000	.....	10,200,000	3,610,000	18,092,000	45,769,000
1892	12,642,000	.....	9,915,500	3,705,000	21,962,480	48,224,980
1893	8,808,934	.....	6,195,151	2,411,092	16,322,056	33,737,233
1894	10,029,156	.....	4,845,847	3,199,585	9,231,330	27,305,918
1895	8,894,328	.....	4,961,314	2,825,719	9,974,222	26,655,583
1896	7,944,994	.....	4,773,199	2,859,136	8,387,900	23,965,229
1897	8,905,075	.....	4,965,445	3,870,584	9,153,295	26,894,399
1898	8,396,445	$927,961	5,724,412	3,629,910	9,956,417	28,635,175
1899	10,343,298	1,275,041	5,725,395	4,011,681	13,889,302	35,244,717
1900	10,999,417	1,706,200	6,471,384	4,267,253	13,556,523	36,970,777
1901	14,266,104	1,710,357	8,138,680	4,965,699	18,202,843	47,284,153
1902	16,083,475	2,181,157	10,594,483	5,044,192	20,895,385	54,798,682
1903	15,708,793	2,732,294	11,202,259	5,362,686	22,372,109	57,438,141
1904	17,191,479	2,823,546	10,273,891	6,297,835	22,178,964,	58,765,715
1905	17,563,139	3,074,554	10,006,774	7,129,071	26,025,210	63,798,748
1906	18,562,805	3,736,571	9,169,337	7,582,938	27,327,142	66,378,794
1907	18,064,708	4,594,103	8,871,678	7,837,685	31,737,631	71,105,805
1908	18,420,080	4,282,406	7,594,091	7,783,920	27,632,002	65,712,499
1909	19,581,597	5,133,842	8,010,454	6,548,905	32,070.401	71,345,199
1910	20,541,967	6,452,141	7,930,019	6,992,779	34,603,678	76,520,584
1911	21,194,228	6,739,141	7,730,868	7,546,718	33,897,612	77,108,567
1912	19,223,302	7,560,049	6,893,611	7,786,458	36,729,800	78,193,220
1913	20,733,217	9,134,494	7,248,965	7,870,890	38,745,429	83,732,995
1914	20,160,730	7,865,998	7,501,808	8,121,412	33,894,155	77,544,103
1915	17,864,439	8,489,222	6,095,800	6,916,025	35,229,866	74,595,352
1916	17,418,582	7,666,297	5,603,778	7,033,171	41,319,871	79,041,699
Percentage of increase or decrease for 1916	−2.5	−9.7	−8.1	+1.7	+17.3	+5.96
Percentage of total	22.0	9.7	7.1	8.9	52.3	100.00

[a] Figures 1880-1888, inclusive, represent practically building stone only.
[b] As the meaning of the term "trap rock" has been variously interpreted and has been made in some localities to include a number of widely different rocks, it is here replaced by the title "basalt and related rocks." Prior to 1898 the value of basalt and related rocks was included in that of granite.
[c] Furnace flux only.
[d] Bluestone only.

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Granite.—Granite, comprising 22 per cent of the total value of stone in 1916, continued for the third consecutive year to decrease in total value, its decline in 1916 being 2.5 per cent, following a decline in 1915 of 11.4 per cent. The variety showing the largest decline was granite for building, about 12 per cent, following a decline of 23 per cent in 1915. The decline in 1916 was nearly four-fifths of the total gains made by four other uses. Crushed granite, which declined nearly 4 per cent in 1915, decreased more than 7 per cent in 1916. Other varieties showing decrease in 1916 were paving, flagging, and rubble, paving having declined in 1915 also. Monumental granite, on the other hand, after a decrease of 3 per cent in 1915, continued the gain begun previously and established a new record value. Its gain in 1916 was 7 per cent. The steadily increasing popularity of granite as a monumental stone is shown by the fact that in only three years (1909, 1911, and 1915) since 1904 has its value of production decreased. Granite for riprap, curbing, and "other uses" also showed gain in 1916.

Basalt and related rocks (trap rock).—Basalt and related rocks, representing 9.7 per cent of the total value of stone in 1916, also declined in value 9.7 per cent after an increase of 7.9 per cent in 1915. Its principal product, crushed stone, continued to increase in 1916, but this increase was more than offset by a decrease of 54 per cent in the value of riprap. Of the remaining products, rubble and building stone showed increase, but paving a larger decrease, and curbing and "other uses" also decreased.

Marble.—Marble, representing 8.9 per cent of the total value in 1916, increased 1.7 per cent in value in that year after a decrease of 14.8 per cent in 1915. A decrease of 2.5 per cent in value of marble for building was more than compensated by a gain of nearly 10 per cent in marble for monumental work. The gain in value of monumental marble in 1916 followed larger declines in 1914 and 1915 and fell far short of the values for all previous years since 1903 except 1909.

Limestone.—Limestone, which represented 43.8 per cent of the total value of stone in 1914 and 47.2 in 1915, represented 52.3 per cent in 1916. Its increase of $6,090,005, or 17.3 per cent, in 1916 was about 3½ times the total decrease of granite, basalt, and sandstone. Nearly five-sixths of this increase was in the value of limestone for flux, which was second only to that for crushed stone. The remainder of the increase was chiefly in the value of crushed stone and building stone. The increase in value of limestone for building in both 1915 and 1916 was the exception, as granite, marble, and sandstone decreased. Continued small increase was also made by riprap and flagging, that for riprap alone exceeding the combined small decrease in paving, curbing, and rubble.

Sandstone.—Sandstone continued the decline which has been general since 1903, interrupted by increases in only three years, 1909, 1913, and 1914. The decrease of $492,022, or 8.1 per cent, in 1916 brought the total value down to a lower figure than in any year since 1897, when it was $4,965,445. Considerable increase was made, however, in sandstone for riprap and "other" uses (chiefly ganister). About one-fourth of the total decrease in sandstone was represented by bluestone, whose value up to 1914, inclusive, had exceeded $1,000,000, but was only $510,011 in 1916.

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PRODUCTION BY USES.

General statistics.—As shown in the table on page 998, the total value of stone for three uses—monumental, crushed, and "other"—increased in 1916 while that of the remaining six uses decreased. Increase or decrease in value according to uses was less affected by local conditions than in preceding years, although a few marked changes, notably decrease of granite and sandstone rubble in California, New York, North Carolina, and Washington, and of basalt riprap in Oregon and Washington, were due to the completion of harbor and railroad construction work. Other local factors worthy of mention were the completion of the Elephant Butte dam which caused a marked decrease in crushed stone for concrete in New Mexico, the large increase in limestone for flux, and in granite for irrigation construction work in Arizona, and the large decrease in crushed stone for road metal in Virginia.

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Value of stone sold in 1915 and 1916, by kinds and uses.

Kind.	Building (rough and dressed).	Monumental (rough and dressed).	Paving.	Curbing.	Flagging.	Rubble.	Riprap.	Crushed.	Other.	Total.
1915.										
Granite	$4,990,627	$4,785,771	$2,349,646	$683,655	$23,197	$502,530	$793,773	$3,823,774	$111,466	$17,864,439
Basalt and related rocks (trap rock)	52,307	.....	146,560	230	.....	128,711	1,732,113	6,397,641	31,660	8,489,222
Sandstone	1,416,842	.....	532,780	890,464	469,777	157,088	362,150	1,849,078	417,621	6,095,800
Limestone	4,056,201	.....	19,396	80,415	7,758	306,116	1,305,636	17,102,996	12,351,349	35,229,866
Marble	[a] 4,864,471	1,873,668	.....	.....	.....	.....	.....	.....	177,886	6,916,025
	15,380,448	6,459,439	3,048,382	1,654,764	500,732	1,094,445	4,193,672	29,173,488	13,089,982	74,595,352
1916.										
Granite	4,305,517	4,952,126	2,293,486	828,761	9,395	254,129	992,788	3,543,416	238,964	17,418,582
Basalt and related rocks (trap rock)	64,277	.....	57,618	.....	.....	186,491	796,048	6,539,008	22,855	7,666,297
Sandstone	1,316,287	[b]	327,264	702,902	389,859	86,938	488,874	1,664,694	626,960	5,603,778
Limestone	4,570,703	[b]	14,237	79,338	10,411	297,772	1,357,457	17,715,834	17,274,119	41,319,871
Marble	[a] 4,744,606	2,079,410	.....	.....	.....	.....	.....	[b]	209,155	7,033,171
	15,001,390	7,031,536	2,692,605	1,611,001	409,665	825,330	3,635,167	29,462,952	18,372,053	79,041,699
Percentage of decrease or increase in 1916	−2.5	+8.9	−11.7	−2.6	−18.2	−24.6	−13.3	+1.00	+40.4	+5.96

[a] Includes stone for both exterior and interior building.

[b] Small values included under "Other."

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Building stone.—The total value of building stone, after a decrease of nearly 14 per cent in 1915, lost only 2.5 per cent in 1916. The table on page 996 shows that limestone was the only building stone of importance to show increase in value in 1916. This is in keeping with the prevailing character of buildings erected during the year. Although building activity in 1916 was very great, the number of permits issued for new stone buildings in 129 of the leading cities as shown in the chapter summarizing building operations was only 503 in a total of 137,004 new buildings, and the value of these new stone buildings was $8,578,863, or 1.21 per cent, in a total of $707,584,797. Many apartments, dwellings, and factories were erected, but few large office buildings. Several of the larger stone buildings, including important structures erected by Federal and State governments, were faced with limestone, and in addition a great many of the other buildings contained steps, sills, or trimmings of limestone. Sandstone also is adapted to these uses but is evidently not in as great demand. Granite, on the other hand, which has been largely restricted to use in the more costly structures and to base courses and steps of some of the less costly stone buildings and a small number of other buildings, underwent a considerable decrease. The value of marble stated in the table includes $1,458,232 for exterior and $3,286,374 for interior use. So far as cost for exterior work is concerned marble is between limestone and granite and its value in 1916 decreased $562,009 as compared with 1915. The value of interior marble, however, increased $442,144 in 1916, as considerable quantities of it were used both in stone buildings and in the more pretentious of other buildings.

As these conditions existed before the United States entered the war, and as building in general has greatly slackened, no improvement is to be expected for 1917, or indeed so long as the war continues. The following statement [1] regarding conditions in Great Britain is of interest in this connection:

The British mineral statistics for 1916, lately published, are interesting as an index of what may happen to our own mineral industry, the United States having entered the war under conditions similar to those of Great Britain—that is, both were essentially nonmilitary nations—and both were obliged to withdraw from peaceful pursuits a large percentage of the working population. Unfortunately, the mineral industry of Great Britain is far less diverse than that of the United States, and in the production of metalliferous minerals is relatively unimportant, except for iron ore.

The noteworthy feature of the British statistics is their exhibition of how the production of the essentials has been fairly well maintained, while the nonessentials have fallen off to a much larger extent. Thus, comparing the figures for 1913 with those of 1916, we find that in the former year there was a production of 287,430,473 tons of coal, 15,997,328 tons of iron ore, and 3,280,143 tons of oil shale. In 1916 coal production had declined to 256,375,366 tons, iron ore to 13,494,658 tons, and oil shale to 3,009,232 tons. Turning now to nonessentials, if we may be permitted thus to characterize the rocks, we find that gravel and sand declined from 2,409,152 tons to 1,961,650 tons. Igneous rock declined from 7,098,493 tons to 4,843,176 tons. Limestone declined from 12,740,664 tons to 10,541,573 tons. Sandstone declined from 3,977,303 tons to 1,999,308 tons. If our interpretation be correct, the decline in the production of sand and rock reflects curtailment in domestic building operations, things not immediately necessary having manifestly been postponed. On the other hand, attention has been concentrated on the production of coal and iron, which are indispensable, and their output has been pretty well maintained.

Forecasters of the condition of industries after the war are wont to refer for comparison to conditions in the years closely following the

[1] Eng. and Min. Jour., Nov. 11, 1917, p. 893.

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Civil War. There are no statistics, however, sufficiently complete, to show the effect of the Civil War in depressing the building industry or the stone industry, which then consisted chiefly of the production of building and monumental stone, nor is there anything to indicate recovery after that war. The increase in production during the years prior to 1880 rather reflects the normal growth of the country, as does the increase in total value of stone since 1896, when concrete was attaining marked prominence as a building material.

The value of exterior building stone, however, as shown in figure 22, page 1071, was greatest in 1902 and 1906, and since then has declined as a rule and has become practically limited to the facing of the more costly public and office buildings and to trimmings in brick buildings. Curtailment of building in general is likely to have particularly disastrous effect on the production of exterior building stone, as the difficulties with labor and transportation, the high cost of other building materials, and the demand for those materials in other industries or in rapidly constructed buildings for those industries all tend to delay or prevent construction of the more costly buildings. Even Federal building is being curtailed because of these conditions.

According to James A. Wetmore, Acting Supervising Architect, Treasury Department,[1] the cost of building material and labor, abnormally high at the beginning of the last fiscal year (July 1, 1916), maintained an upward tendency throughout the year in many lines and nowhere showed a decrease. Contractors reported difficulty at times in obtaining quotations from producers of certain materials where definite time for delivery was involved. Car shortages and freight embargoes were frequent occurrences, sometimes lasting for a considerable period. These and other causes contributed appreciably to increase the cost of construction of public buildings and to retard their completion. Whereas there were 63 public buildings and 5 extension and remodeling projects completed during the fiscal year, contracts were placed for 76 buildings and for 7 extension or remodeling projects. Plans and specifications were prepared for 34 other buildings, but no awards were made, as by reason of the advance in costs all bids were in excess of the limits fixed in the authorizations. By altering the plans or substituting other types of construction it is expected that some of the construction work can be carried on within the cost limits. An increase in number of contracts let might give some encouragement to stone producers, although it is not known what proportion of the plans involve stone or partly stone buildings; on the other hand, alteration of plans might decrease the number of buildings that were intended to be of stone.

The high cost of all structural materials may, however, result advantageously in some respects to the building-stone industry. Steel is not only high priced, but much that would normally be used in building is now required for other purposes. Cement in 1917 is bringing a higher price than in any year since 1900. On the other hand there are on the dumps of building and monumental stone quarries large quantities of well-seasoned stone rejected because of some minor defect in appearance or because its shape or size were not adapted to the most rapid work in stone mills. If these large sources of stone, perfectly satisfactory as regards strength and durability, can be drawn upon at this time for foundations, inner walls,

[1] Architect Ann. Rept., 1917, pp. 3–6.

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and exterior walls that do not call for special architectural treatment there will be conservation of both steel and stone.

In the Bedford-Bloomington district, Indiana, the usual price of waste stone sold to lime and pulverized limestone plants of the district has been 15 cents a ton f. o. b. quarry and the railroad charge for moving cars in the district has been $2 a car, making the cost of delivered stone about 20 cents a ton.[1] Freight rates to more distant points would of course be greater and cost of shaping the stone for masonry work would further increase the cost above stated, but not sufficiently to prevent the use of the stone in competition with other materials.

Cost of shaping granite blocks for masonry will be greater than that of limestone and sandstone, but this difference is more than balanced by transportation costs from more distant sources and by the present shortage of cars. Granite from districts on the coasts of Maine and Massachusetts can be cheaply conveyed in small schooners to the large cities of the Atlantic coast.

Besides large blocks for foundations and walls of large buildings, it may be practical to manufacture stock sizes of small blocks. This idea has been adopted by the Indiana Limestone Quarrymen's Association, which now advertise "limestone brick" or small blocks sawed on six sides, at a price which compares favorably with competing materials. The suggestion is warranted that the manufacture of small sandstone, marble, and granite blocks may also be successfully begun. Granite paving blocks cut according to the latest specifications, which require true edges and sides, sell f. o. b. quarry at an average price of about $50 a thousand. Blocks of somewhat larger uniform size if produced in numbers so large as to enable stone contractors to keep a stock on hand, may also be marketable.

It is true that adoption of these uses of stone that has heretofore been wasted may call for change in plans and styles of construction, but when unusual economic conditions prevail changes to meet them are in order. The present crowding of large cities and manufacturing centers is reaching a point that may require additional building, even at prevailing high prices. Many of the buildings required will be small wooden dwellings calling for little or no stone as stone has been used in recent years. Others will be of larger size and of fireproof materials that can be quickly supplied, but not of the costly type that usually calls for cut stone. If stone already quarried can be marketed quickly and in stock sizes and shapes to meet this demand, an output may be maintained that will help to tide over the period of depression that appears inevitable in the production of high-class cut stone during the war. The long period of depression in the building-stone trade from 1893 to 1896 was followed by one of increasing production from 1897 to 1902, a period in which other building materials also showed great increase in output. It is therefore reasonable to hope that the present curtailment in erection of high-class stone buildings will be compensated when industrial conditions become normal.

Monumental stone.—Sales of monumental stone after decreasing 2 per cent in value in 1914 and nearly 10 per cent in 1915 increased about 9 per cent in 1916. The decreases of 1914 and 1915 were in

[1] Mance, G. C., The utilization of waste stone: Indiana Dept. Geology and Mineral Resources Thirty-ninth Ann. Rept., p. 234, 1914.

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marble, which overbalanced moderate gains in granite, but both marble and granite increased in 1916. Improved conditions began in the last two months of 1915 and continued in spite of interruptions during 1916. Nation-wide car shortage and freight embargoes were complained of more in some centers than in others. Strikes lasting from March 1 into April curtailed production in two granite centers, and bad weather retarded local operations to a small extent elsewhere. Further comment regarding local conditions in 1916 is given in descriptions of granite and marble industry in different States. As noted in the introduction, the increase in sales of monumental stone is in keeping with the marked prosperity that characterized many industries in 1916, whereby individuals as well as associations had funds available for esthetic and artictic as well as for more essential enterprises. Continuation of this prosperity during the first half of 1917 has apparently had its beneficial effect on the monumental stone industry, but the high prices of food, clothing, and fuel, and the nation-wide subscriptions to the war loans may retard sales during the latter part of the year and in 1918. Increased traffic congestion and preference granted to products of greatest necessity in war time has been also more keenly felt during the closing months of 1917.

Paving stone.—Paving stone continued to decrease in value—4 per cent in 1914, 24 per cent in 1915, and nearly 12 per cent in 1916. All kinds of paving stone showed decrease in 1916. Granite, which represented 85 per cent of the total value, showed by far the smallest proportionate decrease, and even a much smaller actual decrease than sandstone and basalt and related rocks. The marked decrease in sandstone and limestone is in keeping with the increasing use of various crushed stone pavements with concrete or bituminous binder. In many large cities traffic for the most part is not so heavy that sandstone blocks of superior crushing strength and wearing qualities are necessary. In the larger cities, however, where much of the traffic is extremely heavy the strongest paving blocks, chiefly granite, continue to be in demand. In fact granite paving blocks have become especially restricted to districts of extremely heavy traffic in late years, and it is significant that the decrease in value of granite paving blocks in 1916 is less than the curtailment of normal output caused by a strike in one important producing center.

The new variety of paving called "durax" and consisting of small 3 to 4 inch cubic blocks has gained prominence in the last few years. Both granite and hard sandstone blocks have been marketed, but statistics sufficiently accurate for publication have not been collected. It is hoped that the next report will show the quantity and value of "durax" paving marketed in 1917.

Curbing and flagging.—The total value of curbstone also continued to decrease—10 per cent in 1914, 11 per cent in 1915, and nearly 3 per cent in 1916. Granite curbing, however, increased materially, but was more than offset by the decrease in sandstone. The value of limestone curbing almost held its own.

Flagstone, after having decreased 6 per cent in 1914 and 8 per cent in 1915, declined 18 per cent in 1916. Sandstone, which represented 95 per cent of the total value of the flagstone, showed the principal decline, and the little granite used showed a large proportionate decline. Increase in the small quantity of limestone used was too small to affect the total value materially.

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This continued decrease in curbing and flagging, resulting from the increased use of concrete for these purposes, calls for little comment. The increase in granite curbing evidently indicates increased construction work along streets of heavy traffic.

Rubble and riprap.—Rubble and riprap, like paving, curbing, and flagging, continued to decrease in value. Rubble decreased 21 per cent in 1914, 15 per cent in 1915, and nearly 25 per cent in 1916. Large decrease was shown by granite and sandstone and a small decrease by limestone, but basalt and related rocks showed considerable increase. These decreases indicate for the most part completion of local work, and doubtless also preference for concrete in the rapid construction work that characterized 1916. As already stated, however, the high cost of other structural materials and the shortage of some of them may give producers of rubble for local trade an opportunity to increase their output, particularly in those communities where rapid increase in population and business activity caused by war industries is likely to call for renewed rapid construction.

Riprap decreased 12 per cent in 1914, increased 12 per cent in 1915, and decreased more than 13 per cent in 1916. Granite, sandstone, and limestone showed some increase, but their combined increase did not equal the large decrease of basalt and related rocks. Completion of the river and harbor work in Washington and Oregon that accounted mainly for the increase in 1915 caused the decrease in 1916.

Crushed stone.—Crushed stone, after decreasing in value 5 per cent in 1914 and 3 per cent in 1915, increased 1 per cent in 1916. Discussion of crushed stone is given on pages 1067 to 1078.

Other uses.—Stone for "Other uses," mainly limestone, includes that used in important metallurgical and chemical industries, and its increase or decrease in value reflects the state of those industries. This group, therefore, showed a decrease in value of 22 per cent in 1914, when industrial conditions generally were dull, and increase of 16 per cent in 1915 and of 40 per cent in 1916, when related industries were remarkably active. The greatest increase in 1916 was in limestone, nearly all for flux, and in sandstone or quartzite for ganister.

"Other uses" include under granite and basalt (trap rock) rough stone sold by producers to paving cutters and crushing plants, stone for well covers, fence posts, kollar-gangs in paper mills, and chicken grit, and stone whose uses were not specified by producers; under sandstone, ganister (valued at $529,805 in 1916), and stone sold locally for tombstone bases, covers, grit, stone for crushing plants, and for paving blocks; under marble, material sold as crushed stone, flux, terrazzo, and marble dust; under limestone, flux (valued at $13,936,882), stone for sugar factories (valued at $369,694), pulverized stone for agriculture (valued at $1,146,582), and stone for less important uses whose values are noted in the table on page 1058.

PRODUCTION BY STATES.

Pennsylvania and Ohio, as shown in the following table, continued to rank first and second, respectively, in 1916 in total value of stone sold, and both showed increase, Pennsylvania's value increasing $1,711,258, or more than 18 per cent. This increase was due mainly to limestone for flux and raised Pennsylvania's percentage of the

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country's total from 12½ to nearly 14. Vermont, with a relatively small gain, displaced New York for third place; Illinois advanced from eighth to sixth place, changing places with California; Virginia, with a greatly decreased output of crushed stone for road building, dropped from ninth to seventeenth place; and Michigan, with an increase of $550,616, gained tenth place and became one of the 11 States having sales valued at more than $2,000,000. Of the other States, North Carolina made a noteworthy increase of $577,913, rising from nineteenth to twelfth place, and Alabama, Indiana, West Virginia, Wisconsin, Minnesota, Kentucky, and Arizona made large increases. Of the 48 producing States, 18 decreased, including among the leading States New York, Massachusetts, California, and Virginia. Washington and Oregon also showed large decrease, owing to completion of river and harbor work mentioned on page 1035.

Value of stone sold in the United States, 1915 and 1916, by States.

1915.

Rank of State.	State or Territory.	Total value.	Percentage of total.	Number of plants.
1	Pennsylvania	$9,310,397	12.48	628
2	Ohio	5,816,923	7.80	269
3	New York	5,731,849	7.68	232
4	Vermont	5,620,899	7.54	49
5	Indiana	4,204,192	5.64	109
6	California	3,516,079	4.71	142
7	Massachusetts	3,326,057	4.46	127
8	Illinois	2,907,410	3.90	93
9	Virginia	2,586,427	3.47	78
10	Wisconsin	2,412,741	3.23	187
11	Missouri	2,145,501	2.88	175
12	Michigan	1,943,668	2.61	35
13	Tennessee	1,814,782	2.43	67
14	Washington	1,758,817	2.36	29
15	Georgia	1,720,313	2.31	35
16	New Jersey	1,601,044	2.15	76
17	Minnesota	1,492,341	2.00	89
18	Colorado	1,425,270	1.91	49
19	North Carolina	1,409,963	1.89	42
20	New Hampshire	1,234,149	1.65	34
21	Connecticut	1,134,947	1.52	56
22	Kentucky	1,071,052	1.44	98
23	Maine	1,062,283	1.42	57
24	West Virginia	1,047,695	1.40	71
25	Maryland	916,525	1.23	51
26	Oregon	753,285	1.01	27
27	Texas	726,323	.97	45
28	Alabama	719,452	.96	25
29	Rhode Island	698,950	.93	20
30	Kansas	537,165	.72	68
31	Iowa	536,175	.72	64
32	Oklahoma	430,302	.58	27
33	Florida	354,673	.48	18
34	South Carolina	321,612	.43	19
35	Nebraska	321,341	.43	18
36	New Mexico	306,309	.41	7
37	Utah	288,306	.39	20
38	Montana	263,312	.35	14
39	Arkansas	255,681	.34	19
40	Hawaii	213,122	.29	8
41	South Dakota	159,089	.21	25
42	Alaska	(a)	(a)	2
43	Delaware	131,379	.18	5
44	Arizona	90,512	.12	12
45	Wyoming	70,576	.09	6
46	Louisiana	(a)	(a)	1
47	Idaho	31,228	.04	7
48	District of Columbia	5,775	.01	5
	Undistributed	171,369	.23	.....
		74,595,352	100.00	3,278

a Included in "Undistributed."

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Value of stone sold in the United States, 1915 and 1916, by States—Continued.

1916.

Rank of State.	State or Territory.	Total value.	Percentage of total.	Number of plants.
1	Pennsylvania	$11,021,655	13.94	516
2	Ohio	6,611,266	8.36	183
3	Vermont	5,691,420	7.20	55
4	New York	5,342,954	6.76	197
5	Indiana	4,657,813	5.89	105
6	Illinois	3,403,094	4.31	91
7	Massachusetts	3,138,165	3.97	118
8	California	3,133,305	3.96	126
9	Wisconsin	2,757,790	3.49	131
10	Michigan	2,494,284	3.16	45
11	Missouri	2,242,742	2.84	155
12	North Carolina	1,987,876	2.52	44
13	Minnesota	1,833,800	2.32	84
14	Georgia	1,799,210	2.28	39
15	Tennessee	1,753,180	2.22	66
16	New Jersey	1,655,692	2.09	79
17	Virginia	1,605,161	2.03	72
18	West Virginia	1,500,809	1.90	60
19	Kentucky	1,403,110	1.78	119
20	Alabama	1,202,256	1.52	25
21	Connecticut	1,143,011	1.45	52
22	New Hampshire	1,141,810	1.44	28
23	Maine	1,068,485	1.35	51
24	Colorado	975,794	1.23	47
25	Maryland	921,909	1.17	53
26	Washington	908,635	1.14	26
27	Texas	698,449	.88	37
28	Rhode Island	632,452	.80	18
29	Oklahoma	621,056	.79	32
30	Kansas	603,490	.76	65
31	Iowa	561,084	.71	64
32	Florida	479,537	.61	18
33	South Carolina	447,940	.57	20
34	Oregon	443,524	.56	29
35	Alaska	(a)	.....	2
36	Nebraska	406,707	.51	17
37	Hawaii	393,477	.50	9
38	Arkansas	374,465	.47	16
39	Utah	368,705	.47	16
40	Arizona	306,579	.39	15
41	Montana	261,460	.33	13
42	South Dakota	205,497	.26	18
43	Delaware	121,354	.15	5
44	Idaho	96,382	.12	7
45	New Mexico	77,290	.10	6
46	Wyoming	64,509	.08	6
47	Louisiana	(a)		1
48	District of Columbia	3,315	.62	5
	Undistributed	483,901		
		79,041,699	100.00	3,036

a Included in "Undistributed."

The total number of active quarries continued to decrease, and was 242 less than in 1915. This large decrease was mainly among the small quarries supplying local trade and is doubtless attributable to marked increase in cost of operation and to scarcity of labor.

EXPORTS.

The total value of stone exported in 1916 was $1,480,750, greater by 43 per cent than in 1915, it also exceeded the value in 1914, but was less by 20 per cent than the record value in 1913. The value of manufactured stone exported increased about 70 per cent in 1916, the unmanufactured portion having practically the same value as in 1915, as is shown in the following tables compiled from statistics furnished by the Bureau of Foreign and Domestic Commerce of the Department of Commerce.

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Stone exported from the United States 1913–1916.

Kind.	1913	1914	1915	1916
Marble and stone, unmanufactured	$606,745	$559,556	$400,510	$403,303
All other	1,250,147	803,686	635,614	1,077,447
	1,856,892	1,363,242	1,036,124	1,480,750

Comparison of exports to different countries given in the table below shows that the increase in 1916 was well distributed among the different continents. The largest actual increase in value—$217,115, or 35 per cent—was in exports to North American countries. About 57 per cent of the total value represented stone shipped to these countries. Canada, as usual, received the greatest proportion (82 per cent), showing increase in both manufactured and unmanufactured stone. Cuba ranked second, receiving stone valued at 10 per cent of the total, and also showing a marked increase, as did Panama.

Exports to Europe represented more than 25 per cent of the total value, and, in spite of generally adverse conditions caused by the war, showed a total increase in value of $168,600, or 83 per cent. Great Britain was, as usual, the largest consumer, representing 45 per cent of the total value and showing a material increase. Italy ranked second and showed the greatest increase in value.

Asia, South America, Oceania, and Africa ranked after Europe, with British East Indies, Argentina, Australia, and British South Africa the principal consumers. Oceania was the only group of countries that showed decrease in total value of exports.

Stone (including marble) exported from the United States in 1915 and 1916.

Country.	Manufactured.	Unmanufactured.
1915.		
Europe:		
Denmark	$16,026	$827
France	15,941	466
Great Britain	109,819	6,857
Greece	2,407	.....
Italy	6,897	7,943
Netherlands	14,659	.....
Russia	15,712	83
Sweden	1,864	142
Other Europe	3,399	81
	186,724	16,399
North America:		
Canada	194,328	352,902
Newfoundland, Labrador, etc.	8,742	6,680
Mexico	5,823	5,418
Central America	3,043	1,370
Panama	7,474	2,989
Cuba	21,293	3,261
Jamaica	3,519	195
Other British West Indies	3,690	321
French West Indies	2,268	41
Other West Indies	2,929	266
	253,109	372,743
South America:		
Argentina	8,563	12
Brazil	6,962	100
South America—Continued.		
Chile	$9,564	$10
Colombia	4,830	658
Peru	6,441	27
Uruguay	1,500	310
Venezuela	3,239	12
Other South America	1,517	4
	42,616	1,133
Asia:		
China	10,281	.....
British East Indies	50,316	1,077
Dutch East Indies	4,070	.....
Japan	5,959	424
Other Asia	65	.....
	70,691	1,501
Oceania:		
Australia	47,273	5,951
New Zealand	10,285	634
Philippine Islands	4,057	2,101
Other Oceania	565	.....
	62,180	8,686

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Stone (including marble) exported from the United States in 1915 and 1916—Continued.

Country.	Manufactured.	Unmanufactured.
1915.		
Africa:		
British South Africa	$17,837	$48
Other Africa	2,457	.....
	20,294	48
Total exports	635,614	400,510
Grand total	1,036,124	
1916.		
Europe:		
Denmark	8,146	5
France	33,129	1,779
Great Britain	162,063	7,609
Greece	2,904	.....
Italy	93,843	.....
Netherlands	10,307	300
Norway	9,416	3,873
Russia	2,799	.....
Sweden	3,100	.....
Other Europe	31,782	668
	357,489	14,234
North America:		
Canada	325,274	368,135
Newfoundland	6,550	2,607
Mexico	9,027	3,606
Central America	6,973	693
Panama	19,292	1,794
Cuba	77,418	6,824
Bermuda	721	10
Jamaica	5,622	33
Other British West Indies	1,793	83
French West Indies	218	.....
Other West Indies	5,903	389
	458,791	384,176

Country.	Manufactured.	Unmanufactured.
1916.		
South America:		
Argentina	$41,993	$201
Brazil	15,729	1,636
Chile	8,738	450
Colombia	12,630	699
Peru	4,890	145
Uruguay	1,681	.....
Venezuela	3,630	115
Other South America	4,068	134
	93,349	3,380
Asia:		
China	4,439	.....
British East Indies	62,311	.....
Dutch East Indies	7,354	.....
Japan	10,901	1,011
Other Asia	25,534	15
	110,539	1,026
Oceania:		
Australia	21,643	110
New Zealand	11,269	.....
Philippines	1,497	7
Other Oceania	207	.....
	34,616	117
Africa:		
British South Africa	20,360	370
Other Africa	2,303	.....
	22,663	370
Total exports	1,077,447	403,303
Grand total	1,480,750	

Lack of data regarding the kinds and uses of stone exported is regretted, as such information would be of much interest when compared with statistics of production and exports of stone from other countries. For example, Canada's production of stone in 1916 ($3,736,412) showed a decrease of $508,585, or more than 12 per cent.[1] Of this total value, limestone contributed $2,224,091, granite $1,247,267, sandstone $146,244, and marble $118,810. Building stone represented $1,173,642, or 31.4 per cent of the total value, and monumental and ornamental stone represented $183,086, or 4.9 per cent, crushed stone $1,408,515, or 38 per cent, and flux $480,230, or 13 per cent. Imports of stone into Canada in 1916 amounted to $587,304 in value, $437,310 representing imports from the United States, $90,100 imports from Great Britain, $386 imports from Italy, and $59,508 imports from other countries. The discrepancy between the Canadian figures for imports from the United States and the United States figures for exports to Canada may be both because the stone exported late in 1916 was not received in Canada until early in 1917 and because of difference of classification, the United States figures including certain products as stone that are not so classified by Canada.

[1] McLeish, John, Production of cement, lime, clay products, stone, and other structural materials in Canada in 1916 (advance chapter of annual report on the mineral production of Canada, 1916), Canada Dept. of Mines, Mines Branch, 1917.

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Stone imported into Canada in 1916.

	Imports from the United States in 1916.		Total imports in 1916.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Building stone, rough [a]	.....	$68,939	.....	$68,939
Building stone, dressed [b]	.....	43,171	.....	43,410
Refuse stone [c]	279,884	122,217	363,682	169,877
Granite, sawn only	.....	4,511	.....	5,049
Granite, manufactures of	.....	7,944	.....	91,939
Manufactures of stone, n. o. p	.....	32,882	.....	36,241
Marble and manufactures of:				
Sawn or sand rubbed, not polished	.....	88,864	.....	92,414
Rough, not hammered or chisled	.....	35,792	.....	35,792
Manufactures of, n. o. p	.....	32,990	.....	43,643
	.....	437,310	.....	567,304

[a] Flagstone, granite, rough sandstone, and all building stone not hammered, sawn, or chiseled.
[b] Flagstone and all building stone, sawn or dressed or partly dressed.
[c] Stone refuse not sawn, hammered, or chisled, not fit for flagstone, building stone, or paving.

This table shows that the bulk of imports of stone into Canada in 1916 came from the United States, with the exception of manufactured granite, which came from Great Britain.

IMPORTS.

The term "general imports" in this publication embraces both imported articles entered for immediate consumption on arrival and articles entered for warehouse, as distinguished from the "imports for consumption," which embrace imports entered for immediate consumption and withdrawals from warehouse for consumption. The statement of general imports and the statement of imports for consumption for any period will differ to the extent that the value of the entries for warehouse for the period differs from the value of the withdrawals from warehouse for consumption. The term "entry for consumption" is the technical name of the import entry made at the customhouse and does not imply that the goods have been actually consumed but simply that they have been delivered into the custody of the importer and that the duties have been paid on the dutiable portion.

Stone imported for consumption in the United States in 1916 was valued at $959,367, about 7 per cent more than in 1915 but about 31 per cent less than in 1914, as is shown in the following table:

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Stone imported for consumption in the United States in 1915 and 1916.

Kind.	1914		1915		1916	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Marble:						
In block, rough, etc.....cubic feet..	567,306	$878,284	334,279	$488,157	350,941	$539,125
Sawed.....do....	.....	.....	76	61	51	246
Slabs or paving tiles.....square feet..	279,028	62,828	96,778	18,388	70,545	15,231
All other manufactures.....	.....	158,920	.....	87,429	.....	122,145
Mosaic cubes:						
Loose.....pounds..	.....	30,566	.....	13,697	.....	22,285
Attached to paper.....	.....	1,541	.....	19	.....	.....
	.....	1,127,139	.....	607,751	.....	699,022
Onyx:						
In blocks, rough, etc.....cubic feet..	10,698	31,368	5,944	30,184	9,071	32,282
All other manufactures.....	.....	2,026	.....	522	.....	2,077
	.....	33,394	.....	30,706	.....	34,359
Granite:						
Dressed.....	.....	155,777	.....	134,720	.....	66,331
Rough.....cubic feet..	5,788	2,280	18,956	9,662	23,773	9,366
	.....	158,057	.....	144,382	.....	75,697
Stone (other):						
Dressed.....	.....	15,994	.....	14,254	.....	11,456
Rough (monumental or building stone), cubic feet.....	43,753	25,978	83,758	41,557	95,005	66,337
Rough (other).....	.....	28,911	.....	54,018	.....	82,496
	.....	70,883	.....	109,829	.....	160,289
Grand total.....	.....	1,389 473	.....	892,668	.....	959,367

Imports of marble, including the usual small portion of "onyx marble," amounted to $723,411, or more than three-fourths of the total imports for consumption, and showed a moderate increase compared with 1915, though far below the value for 1914. More than 85 per cent of the imported marble, as is shown in the next table, came from Italy. Mexico and France, the next countries in importance, together furnished less than 10 per cent.

General imports of marble and onyx, rough and manufactured into the United States in 1915 and 1916.

1915.		1916.	
Austria-Hungary.....	$5	Belgium.....	$99
Belgium.....	3,843	France.....	32,069
France.....	31,050	Greece.....	9,688
Germany.....	728	Italy.....	640,805
Greece.....	20,607	Great Britain.....	11,870
Italy.....	553,367	Denmark.....	4,179
Great Britain and Ireland.....	4,012	Spain.....	598
Other Europe.....	260		
Total, Europe.....	613,872	Total, Europe.....	699,308
Canada.....	583	Canada.....	891
Mexico.....	33,129	Mexico.....	35,657
Cuba.....	24	Cuba.....	216
		Guatemala.....	2
Total, North America.....	33,736	Total, North America.....	36,766
Other countries.....	235	Other countries.....	1,614
Grand total.....	647,843	Grand total.....	737,688

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Imports of marble from Greece declined more than 50 per cent in 1916, following a small decline in 1915. According to Consul General Alexander W. Weddell, Athens,[1] the marble industry in Greece is largely in the hands of a single company, whose manager stated that the best quality of Pentelic marble quarried was absorbed by the London market, that the local market took the poorer qualities, and that the American market consumed the bulk of the Tinos green marble, the only marble whose production had not practically ceased in 1915. Shipments to the Antwerp and Hamburg depots had entirely ceased since the outbreak of the war, and those to Great Britain, owing to doubling of the freight rate, had decreased. Orders for Greek marbles from the United States decreased in 1915, evidently owing to the poor demand, and an increase of about 30 per cent in freight rates doubtless accounts in part for the further large decrease in 1916.

Marble entered for immediate consumption at the customs district of New York in 1916.[a]

Rough marble.

Country.	Quantity (cubic feet).	Value.
Belgium	114	$69
Denmark	1,778	3,853
France	46,362	56,739
Greece	331	850
Italy	165,102	265,391
England	374	747
Guatemala	36,240	61,942
	250,301	381,631

Manufactures of marble.

Italy	34	$46

[a] Statement compiled for United States Geological Survey by the Customs Office of New York, Bureau of Foreign and Domestic Commerce, Department of Commerce.

Comparison of these figures with those in the preceding table shows that the greater part of the marble imported from Belgium, Denmark, France, and England was entered at New York, but only minor fractions of that from Italy and Greece. No explanation is offered for the large quantity of marble from Guatemala entered at New York in contrast to the insignificant value recorded for general imports from that country.

The value of imports of "onyx marble" was greater in 1916 than in either 1914 or 1915. The greater part doubtless came from Mexico, the value of whose exports of marble to the United States showed increase in both 1915 and 1916. The greater part of the Mexican "onyx marble" imported into the United States evidently comes through ports of entry on the Pacific coast or the Mexican border.

[1] Quoted in Stone, Sept., 1916, p. 470.

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"Onyx marble" entered for immediate consumption at the customs district of New York in 1916.[a]

Country.	Quantity (cubic feet).	Value.
Greece	2,998	$8,065
Italy	25	75
Mexico	530	1,580
	3,553	9,720

[a] Statement compiled for United States Geological Survey by the Customs Office of New York, Bureau of Foreign and Domestic Commerce, Department of Commerce.

This was all rough onyx, no manufactured onyx being entered.

Total imports of granite, according to the table on page 1009, underwent a much greater decrease in value in 1916 than in 1915. The quantity of rough granite, however, increased in both of these years. According to the New York customs, no rough granite and only a small part of the manufactured granite imported in 1916 for immediate consumption was received in the New York district.

Value of manufactures of granite imported into the New York district, 1916.

Italy	$814	Scotland	$514
Norway	2,320	Hongkong	8
Sweden	2,957	Japan	34
Switzerland	58		
England	1,300		8,005

The decrease in imports of European granite was mainly due to lack of ships for carrying other products than those urgently needed by war industries. About three-fourths of the rough granite worked in Aberdeen, Scotland, comes from Norway, Sweden, and Finland and is of color and quality that are not to be found in the British Isles.[1] The finished product is shipped to England, France, the United States, Canada, Argentina, South Africa, Australia, and New Zealand. As a result of these conditions it is possible that in the future the quantity of manufactured monumental granite heretofore imported into the United States from England and Scotland will be largely replaced by direct imports of rough or manufactured granite from Norway, Sweden, and Finland. Present conditions, due both to scarcity of labor and to natural causes, do not favor a revival of granite quarrying in Great Britain as a result of the stagnation of the granite quarrying industry in the Scandinavian countries, which have also suffered from reduction of exports to Germany. In view of these conditions the increased production of domestic monumental granite in 1916 is of added interest.

It may appear from this statement that the present is an opportune time for producers in the United States to introduce their stone into South American markets. The entrance of this country into the war, however, renders it probable that the concentration of all available shipping for war purposes will prevent the development of the stone trade with South America until after the war. Then the results of

[1] Stone, August, 1916, p. 490.

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the intensive ship building campaign may give this country an advantage that it has not heretofore enjoyed.

Imports of stone other than marble and granite continued to increase in value in 1916. No detailed information is available regarding this group of stone, other than the following statement:

"Freestone" entered for immediate consumption at New York in 1916.[a]

	Quantity (cubic feet).	Value.
Rough freestone:		
France	22,776	$16,822
Italy	46,120	37,537
England	915	694
	79,811	55,053
Manufactured freestone:		
France	.....	15
Italy	.....	4,454
England	.....	3,808
China	.....	18
Japan	.....	192
	.....	8,476

[a] Statement compiled for the United States Geological Survey by the Customs Office of New York, Bureau of Foreign and Domestic Commerce, Department of Commerce.

GRANITE.

GENERAL STATISTICS.

The figures here given as representing the value of granite produced and sold in the United States include the value of small quantities of other crystalline and igneous rocks such as syenite, monzonite, gneiss, schist, tuff, rhyolite, trachyte, and andesite, the quantities of which are too small to be tabulated separately, especially by States. Gabbro and diabase, or "black granite," quarried for monumental work have also been included. Syenite, monzonite, and most gneisses are so closely related, both geologically and commercially, to granite that inclusion of them with granite in this report is desirable; but the other rocks are too different in most respects from granite to be satisfactorily grouped with it, and an effort will be made in future reports to segregate these rocks of minor commercial importance into a group entitled "miscellaneous" and to give statistics regarding them in as much detail as possible without disclosing individual production.

The value of granite produced and sold in the United States in 1916, as shown by the accompanying table, was $17,418,582, or 22 per cent of the value of the entire output of stone. This was a decrease of nearly 3 per cent compared with 1915 and was the lowest recorded production since 1904. Quarrymen generally reported adverse conditions due to use of cheaper material, high wages, poor transportation facilities on account of car and boat shortage, lack of labor, cost of fuel and explosives, and strikes in many districts. Of the 27 States whose sales are separately recorded, only 10 showed increase. Eight States, however, in 1916, compared with seven States in 1915, had marketed production exceeding $1,000,000 each, and together they represented 71 per cent of the total value. These States were, in order of rank, Vermont, Massachusetts, North Caro-

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lina, California, Wisconsin, New Hampshire, Maine, and Minnesota. Of these North Carolina, Wisconsin, and Minnesota were the only States whose sales increased appreciably in value; Maine's increased slightly. North Carolina advanced from fifth to third place owing to increased sales of monumental stone, curbing, crushed stone, and paving blocks. Minnesota, with increased sales of building and monumental stone, entered the group of States whose sales exceeded $1,000,000 in value. Other States with conspicuous increase were Arizona, Georgia, Oklahoma, Oregon, and South Carolina. Vermont, the leading State, whose sales decreased in 1915 underwent an additional decrease of 8 per cent in 1916, owing to diminished value of dressed building stone, which more than offset the gain in value of monumental stone.

Value of granite sold in the United States, 1912–1916.

State or Territory.	1912	1913	1914	1915	1916
Arizona	$26,501	$13,270	$37,831	$71,067	$203,702
Arkansas	[b] 366,354	[b] 378,110	.....	(a)	.....
California	1,583,583	1,451,149	2,386,579	1,656,706	1,433,022
Colorado	55,010	84,497	74,774	65,876	78,823
Connecticut	761,757	765,334	405,655	318,909	270,740
Delaware	193,074	289,987	131,066	131,379	121,354
District of Columbia	.....	.....	.....	5,775	3,315
Georgia	823,207	906,470	958,831	660,454	813,068
Idaho	30,300	113,710	(a)	(a)	.....
Maine	1,803,679	1,790,279	1,717,110	1,062,263	1,068,485
Maryland	749,555	806,259	846,838	662,466	633,218
Massachusetts	2,220,279	2,220,630	2,091,417	2,071,203	1,997,150
Minnesota	950,033	853,111	735,753	841,943	1,048,816
Missouri	97,776	42,484	77,971	85,625	80,390
Montana	28,666	31,520	25,977	28,829	18,175
Nevada	(a)	.....	.....	.....	.....
New Hampshire	1,311,488	1,482,771	1,383,325	1,224,149	1,141,810
New Jersey	142,515	62,537	74,808	95,986	71,421
New Mexico	(a)	(a)	(a)	.....	(a)
New York	431,910	746,826	797,207	747,242	868,119
North Carolina	983,615	1,116,475	1,286,345	1,246,810	1,796,067
Oklahoma	14,460	30,678	24,696	29,141	80,597
Oregon	16,721	37,807	36,852	7,246	17,080
Pennsylvania	575,680	1,102,206	511,013	506,360	446,868
Rhode Island	767,507	642,375	621,630	691,765	631,237
South Carolina	263,905	360,476	357,657	319,090	447,570
South Dakota	(a)	(a)	(a)	22,379	(a)
Texas	67,613	76,067	115,857	86,968	84,379
Utah	8,975	(a)	(a)	(a)	(a)
Vermont	3,047,954	3,782,235	3,120,452	2,778,780	2,560,579
Virginia	470,657	462,162	805,287	899,384	451,697
Washington	140,581	140,279	72,079	260,688	90,525
Wisconsin	1,179,018	927,616	1,341,455	1,256,851	1,390,968
Undistributed	110,929	15,797	122,166	49,175	67,387
	19,223,302	20,733,217	20,160,730	17,864,439	17,418,582

[a] Included in "Undistributed." [b] Includes basalt or trap rock.

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Value of granite sold in the United States in 1915 and 1916.

1915.

State.	Sold in the rough.				Dressed for—		Made into paving blocks.	Curbing, and flagging.	Crushed stone.			Other.	Total.
	Building.	Monumental.	Rubble.	Riprap.	Building.	Monumental.			Road metal.	Railroad ballast.	Concrete.		
Arizona	$3,000	$800	.....	$54,914	$200	$5,000	.....	.....	.....	$7,173	.....	.....	$71,087
Arkansas	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
California	24,896	32,701	$48,644	362,369	231,744	42,705	$42,465	$55,506	$337,964	179,582	$232,902	$4,136	1,556,706
Colorado	2,465	42,114	384	.....	.....	5,760	.....	.....	2,778	.....	12,171	204	65,876
Connecticut	62,636	41,062	1,956	24,555	95,938	40,282	21,899	23,752	1,299	.....	2,308	3,116	318,909
Delaware	8,196	173	22,007	38,084	108	.....	721	3,337	21,707	11,770	25,396	.....	131,379
District of Columbia	.....	.....	5,775	.....	.....	.....	.....	.....	.....	.....	.....	.....	5,775
Georgia	8,396	31,171	16,191	.....	88,183	106,268	108,177	155,896	31,696	26,136	79,383	8,957	660,454
Idaho	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Maine	90,220	58,762	5,397	9,561	265,992	38,054	495,327	88,001	1,409	2,349	4,123	3,088	1,062,283
Maryland	45,796	17,500	1,765	3,922	18,278	9,441	29,732	6,210	193,079	209,582	126,218	993	662,466
Massachusetts	168,264	419,900	22,011	17,002	768,957	12,689	283,612	136,923	103,062	1,402	87,549	48,362	2,071,203
Minnesota	2,560	68,558	3,714	2,295	117,017	504,611	123,940	100	15,540	.....	.....	3,606	841,943
Missouri	3,596	27,357	138	674	.....	.....	42,493	684	4,936	.....	5,287	460	85,625
Montana	.....	2,484	.....	.....	25,545	800	.....	.....	.....	.....	.....	.....	28,829
New Hampshire	69,089	62,349	2,895	9,443	549,702	218,873	205,456	77,644	12,416	.....	11,001	15,281	1,234,149
New Jersey	206	900	1,050	1,971	.....	.....	.....	.....	51,260	38,097	2,500	.....	95,986
New York	14,946	6,188	111,549	130,995	305,987	15,335	70,950	1,166	21,246	5	68,375	.....	747,342
North Carolina	30,865	9,660	49,387	54,039	366,536	10,660	191,796	89,222	61,796	78,765	302,084	2,000	1,246,810
Oklahoma	1,600	9,326	1,700	.....	400	13,940	.....	1,500	75	.....	.....	600	29,141
Oregon	.....	1,538	.....	.....	.....	3,400	.....	.....	.....	.....	.....	2,308	7,246
Pennsylvania	201,739	13,586	27,862	12,340	32,907	57,202	65,560	9,514	32,641	100	50,259	2,150	506,360
Rhode Island	24,830	211,840	3	1,324	60,552	98,176	58,721	15,819	109,302	.....	109,730	468	691,765
South Carolina	5,342	56,000	26,187	4,685	3,150	20,000	.....	9,925	26,566	49,678	117,070	427	319,030
South Dakota	.....	.....	.....	.....	650	16,300	.....	.....	2,535	.....	2,894	.....	22,379
Texas	8,200	35,600	.....	4,738	1,000	36,000	.....	130	.....	.....	1,000	300	86,968
Utah	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a)
Vermont	11,394	1,334,427	.....	1,951	1,088,950	322,268	1,430	1,727	2,804	125	5,874	7,780	2,778,730
Virginia	32,561	8,738	26,862	57,407	810	10,528	26,531	13,728	537,691	88,532	61,046	4,950	869,384
Washington	4,214	4,934	125,208	230	86,446	6,708	2,078	10,880	18,082	.....	.....	908	260,688
Wisconsin	995	17,850	760	294	8,167	473,293	577,758	5,095	73,364	.....	97,905	570	1,256,851
Undistributed	47,400	840	85	.....	.....	100	.....	.....	.....	750	.....	.....	49,175
	873,408	2,516,378	502,530	793,773	4,117,219	2,069,393	2,349,646	706,852	1,664,218	693,996	1,465,560	111,466	17,864,439

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Arizona	(a)	(a)		(a)	(a)	(a)			(a)	(a)	(a)			$203,702
California	$6,933	$25,201	$824	$350,160	$316,864	$96,495	$17,963	$53,611	$196,340	$122,154	$203,833	$40,644		1,433,022
Colorado	7,910	15,276	(a)		(a)	21,040					(a)	(a)		78,928
Connecticut	29,723	50,937	2,360	50,536	35,939	61,188	17,975	14,754	(a)			6,777		270,740
Delaware	(a)	(a)	(a)	53,026	(a)		(a)	(a)	(a)		(a)	(a)		121,354
District of Columbia			2,950									(a)		3,315
Georgia	9,918	36,764	18,099	160	91,066	(a)	105,350	224,560	51,587	29,028	156,801	(a)		813,068
Maine	152,792	51,337		1,961	274,295	48,930	430,753	96,510	3,702	(a)	(a)	137		1,068,495
Maryland	86,481	11,334	4,896	(a)	9,367	7,369	32,646		169,300	194,061	114,755	2,095		633,218
Massachusetts	192,886	412,778	31,738	4,671	636,552	30,685	287,640	167,399	86,798	1,262	97,315	47,416		1,997,150
Minnesota	(a)	68,521	5,447	20,811	243,572	596,918	85,106	(a)	(a)		(a)	200		1,048,316
Missouri	(a)	(a)	(a)	(a)	(a)		37,094	(a)	(a)		(a)	(a)		80,390
Montana	(a)	(a)	(a)		9,665	5,635								15,175
New Hampshire	58,441	56,019	7,024	(a)	436,954	210,170	247,177	79,636	16,233		(a)	22,720		1,141,810
New Jersey	1,517			(a)	(a)				(a)	(a)		(a)		91,421
New Mexico										(a)				(a)
New York	15,230	2,810	(a)	(a)	158,201	(a)	(a)		27,354	(a)	25,457	(a)		368,119
North Carolina	37,544	31,208	84,106	160,140	323,584	64,578	200,851	124,845	88,437	69,210	558,476	55,108		1,796,067
Oklahoma		(a)	(a)	(a)	35,250	15,059						(a)		80,597
Oregon		(a)			(a)	(a)		(a)	(a)					17,080
Pennsylvania	224,360	(a)	22,724	18,903	24,900	(a)	(a)	10,878	21,648	(a)	31,082	(a)		446,868
Rhode Island	26,529	170,511	(a)	(a)	37,923	115,353	35,027	16,270	118,781		82,484	28,150		631,237
South Carolina	1,667	(a)	24,993	20,455	(a)			13,210	(a)	15,160	267,807			447,570
South Dakota					(a)	(a)					(a)			(a)
Texas	1,056	34,541		(a)		(a)		2,400				(a)		84,379
Utah	(a)													(a)
Vermont	20,930	1,547,075	(a)	(a)	641,927	320,919	(a)	(a)	(a)		(a)	8,601		2,560,579
Virginia	27,694	6,010	4,967	60,389	(a)	(a)	19,115	(a)	158,351	54,795	70,061	8,505		451,697
Washington	(a)	(a)	(a)	(a)	24,736	10,858		(a)	(a)		(a)	(a)		90,525
Wisconsin	1,474	23,115	6,359	(a)	(a)	498,511	685,022	1,105	84,274		82,478	(a)		1,390,968
Undistributed	16,416	114,680	37,642	242,076	75,211	188,301	91,167	32,978	157,151	95,669	91,572	18,111		67,387
	929,511	2,658,117	254,129	992,788	3,376,006	2,294,009	2,293,486	838,156	1,179,956	581,339	1,782,121	238,964		17,418,582

a Included in "Undistributed."

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Of the principal kinds classified by uses, monumental granite, curbing, and riprap increased in value in 1916, and building stone, rubble, paving stone, and crushed stone decreased.

BUILDING STONE.

About 25 per cent of the total value of granite produced and sold in 1916 was represented by building stone, compared with 28 per cent in 1915. This was valued at $4,305,517, of which a little more than one-fifth was the value of rough stone. Compared with the corresponding value, $4,990,627, in 1915, this was a decrease of $685,110, or 13 per cent, following a decrease in 1915 of 23 per cent. More than 19 per cent of the total amount was represented by Massachusetts in 1916. Vermont, which led with 22 per cent in 1915, ranked second with 16 per cent in 1916. Vermont, however, led Massachusetts by a small margin in value of dressed building stone. Other leading States in 1916 and their percentages of the total value were: New Hampshire, 12 per cent; Maine, about 10 per cent; North Carolina, about 9 per cent; California, 8 per cent; Pennsylvania and Minnesota, about 6 per cent; New York, 4 per cent; and Georgia, 2 per cent. Comparison of the value of total building stone for these States in 1916 with the value in 1915 shows decrease for Massachusetts, Vermont, New Hampshire, New York, and North Carolina, and increase for Maine, California, Pennsylvania, Minnesota, and Georgia. Vermont's decrease was by much the greatest, and far exceeded the net total decrease. Minnesota's value more than doubled, and California showed an increase of more than $65,000. Pennsylvania, as usual, contributed the most rough stone, showing an increase in 1916, and Massachusetts continued to rank second in this respect.

MONUMENTAL STONE.

Monumental stone (rough and dressed) represented 28 per cent of the total value of granite in 1916, compared with 26 per cent in 1915, and amounted to $4,952,126, an increase of $366,355, or 8 per cent. This increase followed a decrease of 5 per cent in 1915 and an increase of nearly 3 per cent in 1914. Rough stone in 1916, as in preceding years, exceeded dressed stone in value, but the difference was less, rough stone increasing $141,739 in value and dressed stone $224,616. This increase in dressed monumental stone was due mainly to the activity of producers in Wisconsin and Minnesota. Vermont's total, mainly rough stone, was nearly 38 per cent of the country's total in 1916, compared with 33 per cent in 1915 and with 36 per cent in 1914. The other important States with their percentage of the total value of monumental stone were: Minnesota, 13 per cent; Wisconsin, 11 per cent; Massachusetts, 8 per cent; Rhode Island, about 6 per cent; New Hampshire, 5 per cent; California, nearly 3 per cent; and Connecticut, 2 per cent. All of these States except Rhode Island and New Hampshire showed gains in 1916. The greater parts of the values in Minnesota, Wisconsin, New Hampshire, and California represent stone finished by the producer.

This continued increase in value of monumental stone is attributed mainly to the prosperity enjoyed by many individuals in industries favorably affected by the war and is in contrast to the effects of the war on the demand for building stone.

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RUBBLE AND RIPRAP.

The gain in value of rubble sold in 1915 was followed by a large decrease, the value of rubble sold in 1916 being only a little more than half the value in 1915. The decrease was mainly in Washington and New York, where structures were begun and completed in 1915, and, in less degree, in California and Virginia. The only conspicuous gain was made by North Carolina.

The value of riprap, however, continued to gain in 1916, the principal increase being reported from North Carolina, whose value in 1915 had also shown considerable increase. The stone in this State was quarried in Wilson County for jetty work. Gains of more than $10,000 each were reported from Arizona, California, Connecticut, Delaware, Minnesota, South Carolina, and Virginia. The principal decrease was in New York. Harbor improvement work continued in California, but the value of the stone sold for this work in 1916 decreased slightly.

PAVING BLOCKS.

Paving blocks represented 13 per cent of the total value of granite sold in 1916, as in 1915. There were sold in 1916 44,895,796 granite paving blocks, valued at $2,293,486, a decrease of nearly 7 per cent in quantity and of more than 2 per cent in value. This decrease followed a decrease in 1915 of nearly 16 per cent in quantity and of 17 per cent in value from the record figures for 1914. The average price per thousand, which was $49.60 in 1914 and $48.85 in 1915, increased to $51.09 in 1916. Four of the 18 producing States, Maryland, New Hampshire, North Carolina, and Wisconsin, showed increase in quantity and value of sales.

Granite paving blocks sold in 1915 and 1916.

State.	1915		1916	
	Number.	Value.	Number.	Value.
California	990,630	$42,465	556,000	$17,963
Connecticut	448,466	21,899	371,278	17,975
Delaware	16,760	721	(a)	(a)
Georgia	3,639,970	108,177	3,168,927	105,350
Maine	10,910,032	495,327	8,823,252	430,753
Maryland	500,101	29,732	512,242	32,646
Massachusetts	5,580,441	283,612	5,404,377	287,640
Minnesota	1,859,715	123,940	1,292,386	85,106
Missouri	930,600	42,498	698,611	37,094
New Hampshire	4,243,753	205,456	5,486,815	247,177
New York	1,950,000	70,950	(a)	(a)
North Carolina	4,024,677	191,796	4,376,383	200,851
Pennsylvania	1,271,169	65,560	(a)	(a)
Rhode Island	822,243	58,721	530,353	35,027
Vermont	34,800	1,430	(a)	(a)
Virginia	626,213	26,531	449,000	19,115
Washington	22,200	3,078	(a)	(a)
Wisconsin	10,229,714	577,758	11,005,538	685,622
Undistributed			2,220,134	91,167
	48,101,484	2,349,646	44,895,796	2,293,486
Average price per thousand		$48.85		$51.09
Percentage of decrease in 1916	15.7	17.0	6.9	2.4

a Included in "Undistributed."

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The decrease in quantity in 1916, though smaller than that in 1915, was even more general. Wisconsin's increase evidently signifies continuation of the increased demand in the Chicago and neighboring markets, but other increases during 1915 in the interior States were not maintained in 1916. The other three States showing increase in 1916 supplied the same general markets as neighboring States showing decrease, and their amount of increase was insufficient to offset the decrease. Maine's decrease was due, in part at least, to a strike in the Vinal Haven district, which lasted six weeks. Had work continued at the average rate during that period, the New England States as a whole, and probably the entire country, would have equaled or surpassed the production in 1915. As there has been a growing recognition among city engineers and street commissions of the suitability of granite paving blocks for streets supporting heavy traffic, the decrease in quantity of paving blocks sold in 1916 appears due to a decrease in the amount of heavy traffic construction work rather than to competition with other paving materials.

Wisconsin, which ranked second in quantity and first in value in 1915, led in both quantity and value in 1916. Maine, which ranked first in quantity in 1915, was second in both quantity and value in 1916. New Hampshire passed Massachusetts in quantity, ranking third in this respect.

The average price per thousand varied from as low as $32 in California and $33 in Georgia to $66 in Minnesota and Rhode Island. There was little geographic significance to differences in average price, other than a relatively low price for labor in the Southeastern States. The principal controlling factor was apparently the ease with which the blocks could be prepared. Thus the average prices in New Hampshire ($45) and in Georgia ($33), where easily worked granite blocks are abundantly produced, were in contrast to that in Massachusetts ($53), where some of the granites are unusually hard, and with those in Wisconsin ($62) and Minnesota ($66), which are characterized by hard granites. The value of granite paving blocks varies with size and amount of dressing from about $25 to $100 a thousand.

The accompanying table gives the quantity and value of paving blocks produced and sold by the quarrymen. In some States, notably Vermont, a considerable quantity of rough stone is sold to manufacturers who cut the paving blocks and market them. As these firms have no connection with the quarries and as the stone purchased by them is already reported by quarrymen as stone sold for "other purposes," the blocks thus manufactured are not included in the figures of the accompanying table. There was a large output of these blocks in Vermont in 1916, greater than in 1915, and in the Quincy district of Massachusetts. A rough estimate of the quantity thus made is 1,500,000 blocks, valued at $60,000.

Sales of "durax" blocks, small cubical granite blocks ranging from 2¾ to 4 inches in size, according to specifications, were reported by two producers, but are not included in the accompanying table, which represents only the more ordinary sizes of blocks. A small production of "durax" sandstone blocks was reported in Wisconsin. "Durax" blocks are attaining considerable prominence and have much in their favor when considered for roads of moderate to heavy

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traffic. It is hoped that figures showing the production of "durax" blocks can be given in the report for 1917.

Recent bibliography.—The following articles discussing the proper use of the improved granite paving block have recently been published:

Granite for paving: Stone, May, 1916, pp. 243–244 (quoted from article by Z. W. Carter in The American City).
Warren, G. C., Stone and concrete foundations from the standpoint of efficiency and economy.
Pollock, C. D., Present status of physical tests for granite blocks.
Schmidt, H. H., Joint fillers for granite paving block pavements.

Abstracts of the last three papers, read at the annual meeting of section D (Engineering) of the American Association for the Advancement of Science, New York, December 28–29, 1916, were published in Science, April 20, 1917, pp. 391–392.

CURBING AND FLAGGING.

The value of granite for curbing and flagging increased $131,304, or nearly 19 per cent, in 1916. The value in 1916, as in former years, was almost entirely for curbing, that for flagging amounting to only $9,395 in 1916 and $23,197 in 1915. The large increase in value of curbing in 1916 followed continuous decreases in the three preceding years aggregating $214,554. Georgia, the leading State, made by far the largest gain, practically offsetting its large decrease in 1915. Massachusetts and North Carolina, which ranked second and third, also showed considerable gains, North Carolina's value exceeding $100,000 for the first time. Connecticut showed the largest decrease in value, $8,999.

Massachusetts ($3,690) and New Hampshire ($2,716) were the only States whose value of flagging exceeded $1,000, whereas in 1915 Maine, Maryland, Oklahoma, Pennsylvania, and Wisconsin also exceeded that amount.

CRUSHED STONE.

Crushed granite represented more than 20 per cent of the total value of granite in 1916, compared with 21 per cent in 1915 and 20 per cent in 1914. The value of crushed granite for road metal and railroad ballast decreased, but that for concrete increased and nearly equaled the value in 1914.

GRANITE IN INDIVIDUAL STATES.

GENERAL STATEMENT.

Owing to the fact that the quantity of stone is reported in several different units, some of which vary in different States, no attempt has been made to give quantity in any of the preceding tables except that for granite paving blocks. A majority of producers in several of the larger granite States, however, report fairly comparable figures of quantity, and special tables for these States are given in the following pages and show the quantity of granite for different purposes, classified so far as possible by counties. The figures in these tables are given in as much detail as possible, all the totals being the

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exact figures for the kind of product stated at the head of the column. Although the quantities reported from California and Massachusetts are incomplete they are sufficient to serve as a basis for reasonable estimates of the quantity of granite sold for different purposes and are presented as such.

CALIFORNIA.

The value of granite marketed in California, which was $2,386,579 in 1914, declined in 1915 and 1916. According to the few producers who commented on the condition of the industry in 1916 the demand was poor and prices were low. The market, for granite paving and curbing particularly, has been shrinking, owing to increased use of concrete, and at least one quarry has ceased operations in consequence.

The following table gives an estimate of the quantity of granite quarried for different purposes, as well as the actual figures for value:

Granite sold in California in 1916.

Use.	Quantity.	Value.	Use.	Quantity.	Value.
Building:			Paving blocks.....number..	556,000	$17,963
Rough.....cubic feet..	12,022	$6,933	Rubble.....short tons..	1,635	324
Dressed.....do....	114,229	316,864	Riprap.....do.....	628,989	350,160
Monumental:			Crushed stone.....do.....	1,132,881	522,327
Rough.....do....	37,463	25,201	Other a.....do.....	82,245	40,644
Dressed.....do....	31,350	98,495			
Curbing.....do....	57,259	53,611			1,433,022

a Includes chiefly stone used in filling breaks in the lines of railroads caused by washouts.

CONNECTICUT.

Connecticut's sales of granite decreased 15 per cent in 1916. Several producers reported very poor demand, and some also complained of shortage of labor. Higher cost of operating was of course general and higher prices also were reported. Quarries in different parts of the State, including those in one widely known district, were reported idle during most or all of the year, and little hope of improvement was expressed for the near future. The variety in color and texture of the Connecticut granites, enabling them to meet different architectural demands, should be in their favor when revival of high-class building takes place after the war.

GEORGIA.

The value of granite sold in Georgia increased 23 per cent in 1916, but the granite industry did not regain its general condition of 1914. One company reported a strike that lasted two months. Another company reported unfavorable conditions of transportation that restricted its operations to the filling of local demands. The gain in 1916 was due mainly to increased demand for crushed stone, especially for concrete, and some companies reported increased demand for railroad ballast within the State that would last into 1917. The value of curbing sold in 1916 increased largely, and a small gain was shown by building stone, but there were small declines in the value of monumental and paving stone.

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MAINE.

The value of granite sold in Maine in 1916, as shown in the table on page 1022, increased $6,202, or 0.6 per cent, in spite of the prevailing high cost of production, unfavorable transportation facilities both by rail and by sea, and a strike lasting six weeks in the Vinal Haven district, which caused the idleness of 1,000 men.[1] The gain was due mainly to building stone, which as a whole increased 32 per cent in quantity and about 20 per cent in value. The average price per cubic foot of rough stone increased 6 cents, but that of dressed stone decreased 31 cents.

Monumental stone decreased 8 per cent in quantity but increased more than 3 per cent in value, the average price of rough stone increasing 1 cent per cubic foot and that of dressed stone 11 cents.

Sales of paving blocks decreased 19 per cent in quantity and 13 per cent in value, the average price per 1,000 increasing $3.42. Had average production continued during the period of the strike, production in 1916 would have exceeded the sales in 1915, and there might also have been an increase in sales, provided shipping facilities had been adequate, as the demand was good.

Hancock County led in marketed production with 26 per cent of the total value. Its product was used mostly for building and curbing. The product of Kennebec, Knox, and Waldo counties, mostly paving blocks, represented more than 55 per cent of the total value.

[1] Stone, May, 1916, p. 258.

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Granite sold in Maine in 1915 and 1916.

County.	Number of operators.	Building.				Monumental.				Paving.		Curbing and flagging.		Other.	Total value.
		Rough.		Dressed.		Rough.		Dressed.							
		Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (number of blocks).	Value.	Quantity (linear feet).	Value.	Value.	
1915.															
Cumberland, Franklin, Somerset, and York	14	43,281	$8,066	36,585	$133,105	15,642	$8,914	3,170	$3,060	657,380	$27,899	19,771	$5,225	$8,978	$195,247
Hancock	23	318,675	80,528	61,893	48,250	20,000	9,600	4,172	10,008	1,101,838	51,099	164,290	81,775	11,406	292,666
Kennebec, Knox, and Waldo	12	3,199	1,251	41,531	84,412	43,732	23,652	5,624	15,325	9,150,814	416,329	2,025	1,001	5,403	547,378
Washington and Aroostook	8	4,800	375	36	225	17,297	16,596	3,380	9,661	.....	.....	.....	.....	140	26,997
	57	369,955	90,220	140,045	265,992	96,671	58,762	16,346	38,054	10,910,032	495,327	186,086	88,001	25,927	1,062,288
Average price	.....	.....	$0.24	.....	$1.90	.....	$0.60	.....	$2.33	Per M, $45.40		.....	$0.47	.....	.....
1916.															
Cumberland, Franklin, Oxford, Somerset, and York	14	105,418	$9,269	34,290	$85,638	(a)	(a)	28,675	$34,791	(b)	(b)	16,668	$9,084	(b)	$176,238
Hancock	18	407,109	171,127	(a)	(a)	19,200	8,960	4,790	4,000	132,409	5,246	158,883	85,126	$1,055	275,514
Kennebec, Knox, and Waldo	11	(c)	(a)	123,598	158,434	39,566	29,400	(c)	(c)	8,187,053	398,973	4,507	2,300	1,500	590,407
Washington and Aroostook	8	3,090	752	(b)	(b)	17,394	16,949	1,200	6,167	(b)	(b)	.....	.....	(b)	26,326
	51	501,349	152,792	172,880	274,295	83,800	51,337	20,025	48,930	8,823,252	430,753	180,058	96,510	13,868	1,068,485
Average price	.....	.....	$0.30	.....	$1.59	.....	$0.61	.....	$2.44	Per M, $48.82		.....	$0.53	.....	.....

a Included in dressed stone. b Undistributed. c Included in rough stone.

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MARYLAND AND DELAWARE.

Maryland's sales of granite decreased 4 per cent and Delaware's 8 per cent in 1916. Several producers reported a poor year, owing mainly to scarcity of labor, but one company reported better demand. One operator reported no change in price; others reported increase in the latter part of the year of 5 to 20 per cent. The greater part of the output of these States was crushed granite, and rough building stone was next in value.

A new quarry was opened during the year by the Bethesda Blue Granite Co. at Bethesda, Montgomery County, very near the District of Columbia. The stone is a bluish-gray, rather fine grained granite and is quarried for building and monumental work. The quarry is situated close by a spur of the Baltimore & Ohio Railroad, and it is planned to erect a finishing and polishing mill in such a way that the stone may be handled by gravity alone from the quarry to the mill and thence to the railroad.[1] The following is a record of tests made by the Bureau of Standards on granite from this quarry and reported September 18, 1916:

Compression tests:	
Cubes dry, average of three tests..pounds per square inch...	20,478
Cubes soaked two weeks in water, average of three tests.....pounds per square inch..	16,902
Traverse tests: Modulus of rupture, average of four tests...do....	3,749
Absorption tests: Water absorbed by weight, average of three tests.....per cent..	0.14
Apparent specific gravity, average of three tests.....	2.702
Weight per cubic foot of dry stone.....pounds..	168.9
Weight per cubic foot of wet stone.....do....	169.2

MASSACHUSETTS.

The value of granite sold in Massachusetts decreased $74,053, or 4 per cent, in 1916. The value of building stone sold represented nearly 42 per cent of the State's total, and more than three-quarters of this was sold as dressed stone, whose value decreased 17 per cent compared with 1915. Worcester County (Milford district) and Essex County (Rockport-Lanesville-Bay View district) furnished most of this stone. There was a strike lasting two months in the latter district, but in spite of it conditions in general were reported somewhat improved. In certain districts, however, production of building stone was considerably affected by competition with artificial stone. Prices averaged higher in 1916, in consequence of advance in cost of operation.

Monumental stone, chiefly rough stone quarried at Quincy, increased nearly 3 per cent in 1916 and represented 22 per cent of the State's total value. Cost of production increased greatly, however, and a strike lasting some weeks also diminished production. Plans were approved during the year by the governor and the council of the State for the improvement of Hayward Creek, which would increase the Quincy district's facilities for shipping by tidewater.[2]

The number of paving blocks sold decreased 4 per cemt, but their total value increased 1 per cent, owing to an increase in average price

[1] Stone, November, 1916, p. 584. [2] Stone, November, 1916, p. 589.

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of $2.40 a thousand. More than 71 per cent of the paving blocks were made in Essex County, Middlesex and Bristol counties ranking second and third, respectively, in production.

Sales of crushed granite remained practically the same as in 1915, and were divided nearly equal between road metal and concrete aggregate. Middlesex County furnished most of this stone.

Value of granite sold in Massachusetts in 1915 and 1916.

County.	Number of operations.	Building.		Monumental.		Paving blocks.	Crushed stone..	Other.a	Total value.
		Rough.	Dressed.	Rough.	Dressed.				
1915.									
Berkshire, Franklin, Hampden, and Hampshire	6	$16	$40,000	$48,800	$2,000	$1,400	$13,031	$8,660	$113,907
Bristol, Plymouth, and Suffolk	14	56,184	27,245	40	345	39,820	50,716	22,023	196,373
Essex	15	81,783	270,204	.....	.....	190,002	50,461	33,180	634,630
Middlesex	16	11,415	79,049	700	4,015	38,888	12,899	85,908	232,269
Norfolk	14	3,831	1,300	370,330	6,329	.....	29,400	55,471	466,661
Worcester	13	15,035	351,159	30	.....	13,502	26,976	20,661	427,363
	78	168,264	768,957	419,900	12,689	283,612	191,983	225,796	2,071,203
1916.									
Berkshire, Franklin, Hampden, and Hampshire	6	(b)	35,510	41,496	(c)	(d)	(d)	12,740	96,069
Bristol, Plymouth, and Suffolk	12	30,916	62,293	(e)	.....	32,900	72,705	34,480	233,293
Essex	14	122,362	247,308	.....	.....	200,693	46,086	27,196	643,647
Middlesex	19	(a)	38,063	1,400	(c)	40,451	17,678	105,640	203,262
Norfolk	13	(c)	11,150	372,167	(d)	(d)	(b)	46,026	500,543
Worcester	12	20,487	247,929	(d)	.....	11,243	15,006	25,676	320,341
	76	192,896	636,552	412,778	30,685	287,640	185,375	251,224	1,997,150

a Other includes stone sold for riprap, rubble, curbing, flagging, and other minor uses.
b Included in dressed stone.
c Included in rough stone.
d Undistributed.
e Included in other.

An estimate of the quantities of granite sold in 1916 corresponding to the values in the preceding table is as follows:

Building stone:		Paving stone...blocks	5,404,377
Rough...cubic feet	984,872	Curbing and flagging, linear feet	312,221
Dressed.....do	334,267	Rubble and riprap, short tons	66,114
Monumental stone:		Crushed stone.....do	168,015
Rough.....do	471,592	Other.....do	23,107
Dressed.....do	10,408		

MINNESOTA.

The total value of granite sold in Minnesota in 1916 increased nearly 25 per cent, although there were 3 active producers less than in 1915. Building stone increased 37 per cent in quantity and, owing to large contracts for dressed stone, 104 per cent in value. Monumental stone (rough and dressed) increased 50 per cent in quantity and 16 per cent in value, in spite of a strike in the St. Cloud district. The quarries in Stearns County (St. Cloud district), furnished about 87 per cent, or, including Sherbourne County (East St. Cloud), about 95 per cent of the monumental stone quarried in the State. In the

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spring of 1916 the granite industry of the St. Cloud district was favored by a reduced freight rate of nearly 50 per cent which permitted local producers to meet all eastern competition as far east as Chicago and gave them an advantage in Iowa, Nebraska, and other States to the west.[1] The rate applied to car lots, minimum weight 50,000 pounds, and permitted several dealers to load a car in order to make the required weight.

Paving blocks decreased about 31 per cent in both quantity and value, and their average price per thousand was 79 cents less. The output of paving blocks was very evenly distributed throughout the district.

Granite sold in Minnesota in 1915 and 1916.

County.	Number of plants.	Building (rough and dressed).		Monumental (rough and dressed).		Paving blocks.		Crushed stone.		Other value.	Total value.
		Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Number of blocks.	Value.	Quantity (short tons).	Value.		
1915.											
Benton, Lac qui Parle, Redwood, and Renville	6	17,517	$23,231	23,379	$43,349	527,715	$40,826	.....	.....	$4,119	$111,525
Sherbourne	5	25,108	30,399	14,727	32,166	585,000	44,750	12,950	$15,540	4,429	127,284
Stearns	19	27,802	65,947	181,285	497,654	747,000	38,364	.....	.....	1,169	603,134
	30	70,427	119,577	219,391	573,169	1,859,715	123,940	12,950	15,540	9,717	841,943
Average price	.....	.....	$1.70	.....	$2.61	Per M,	$66.64	.....	$1.20	.....	.....
1916.											
Benton, Redwood, and Renville	5	(a)	(a)	15,598	$45,628	304,386	$21,482	(a)	(a)	16,354	242,228
Sherbourne	4	(a)	(a)	27,480	75,000	462,000	34,940	(a)	(a)	9,004	171,252
Stearns	18	18,975	$59,318	287,407	544,811	526,000	28,684	.....	.....	2,523	635,336
	27	96,483	244,506	330,485	665,439	1,292,386	85,106	25,975	$25,884	27,881	1,048,816
Average price	.....	.....	$2.53	.....	$2.01	Per M,	$65.85	.....	$1.00	.....	.....

a Undistributed.

NEW HAMPSHIRE.

The value of granite sold in New Hampshire in 1916 showed a decrease of more than 7 per cent compared with 1915. The number of active operations was 6 less. Some operators reported the demand as poor, with the same prices and increased cost of production; others reported general demand to be about the same as in 1915, and increased demand for paving blocks. A strike affecting 400 men in the Milford district also impeded production.

Rough building stone decreased 2 per cent in quantity and 15 per cent in value. The average price was 46 cents a cubic foot in 1916, 7 cents less than in 1915. Hillsboro County (Milford) produces more than 88 per cent of the total quantity of this stone. Dressed building stone decreased 23 per cent in quantity and 20 per cent in value. Concord, Merrimack County, produced 84 per cent of the output. Marlboro and Fitzwilliam, Cheshire County, usually make a consid-

[1] The Reporter, April, 1916, p. 13.

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erable output of dressed building stone, but in 1916 the output of this county showed a large decrease. The average price of dressed building stone per cubic foot in 1916 was $2.56.

Rough and dressed monumental stone decreased, respectively, 13 and 27 per cent in quantity and 10 and 4 per cent in value. Carroll and Merrimack counties together and Hillsboro County produced about 88 per cent of this stone. The average price was 73 cents for rough and $4.64 for dressed stone.

The production of paving blocks increased 29 per cent in quantity and 20 per cent in value; the average price was $45.05 per thousand in 1916, $3.36 less than in 1915. More than half of the output was from Hillsboro County and more than one-fourth from Merrimack County. Curbing and flagging decreased in quantity but increased in value; the average price was 43 cents per square foot in 1916, an increase of 6 cents over 1915.

The chief producing localities in the State were Redstone, Carroll County; Warren, Grafton County, where a mica schist is quarried and crushed into chicken grit; Fitzwilliam and Marlboro, Cheshire County; Milford, Hillsboro County; and Concord and Suncook, Merrimack County. Hillsboro County produced more than 36 per cent of the total, Carroll, Grafton, and Merrimack counties more than 51 per cent. Cheshire County, which in 1915 produced more than 26 per cent of the total, produced only 12 per cent in 1916. and the slump in this county caused the decrease in the State.

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Granite sold in New Hampshire in 1915 and 1916.

County.	Number of operators.	Building.				Monumental.				Paving.		Curbing and flagging.		Crushed stone.		Other value.	Total value.
		Rough.		Dressed.		Rough.		Dressed.									
		Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (number of blocks).	Value.	Quantity (linear feet).	Value.	Quantity. (short tons).	Value.		
1915.																	
Carroll, Coos, Grafton, Merrimack, Rockingham, and Strafford	11	19,460	$7,694	134,863	$331,481	46,849	$22,183	20,800	$74,700	1,181,753	$49,463	21,326	$7,651	18,772	$15,471	$14,973	$523,616
Cheshire	6	14,691	5,807	79,916	210,546	8,621	6,161	17,131	56,359	884,225	36,341	.....	.....	4,174	2,946	7,927	326,087
Hillsboro	17	96,171	55,588	6,400	7,675	32,217	34,005	24,102	87,814	2,177,775	119,652	190,900	69,993	6,666	5,000	4,719	384,446
	34	130,322	69,089	221,179	549,702	87,687	62,349	62,033	218,873	4,243,753	205,456	212,226	77,644	29,612	23,417	27,619	1,234,149
Average price	.....	.....	$0.53	.....	$2.49	.....	$0.73	.....	$3.53	Per M,	$48.41	.....	$0.37	.....	$0.79	.....	.....
1916.																	
Carroll, Grafton, and Merrimack	7	10,307	$5,365	144,112	$369,124	(a)	(a)	18,793	$82,986	1,458,447	$62,604	38,980	$12,513	(a)	(a)	21,536	584,913
Cheshire	5	4,710	2,396	26,617	67,830	(a)	(a)	7,018	27,834	4,028,368	184,483	.....	.....	10,259	$8,892	4,004	141,585
Hillsboro	16	113,045	50,680			25,989	$27,368	19,500	99,350			148,584	67,123	(a)	(a)	5,442	415,312
	28	128,062	58,441	170,729	436,954	76,625	56,019	45,311	210,170	5,486,815	247,177	187,564	79,636	25,596	22,431	30,982	1,141,810
Average price	.....	.....	$0.46	.....	$2.56	.....	$0.73	.....	$4.64	Per M,	$45.05	.....	$0.43	.....	$0.88	.....	.....

a Not distributed.

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NEW YORK.

Sales of granite in New York in 1916 declined $379,123, or 51 per cent, in value. Business in widely separated parts of the State was reported dull, and cost of production increased. The decline was mainly due to decrease in value of dressed building stone, the principal product of the State.

NORTH CAROLINA.

The value of granite produced in North Carolina in 1916 increased 44 per cent. By far the most important product was crushed stone mainly for concrete. Dressed building stone was next in importance, and paving blocks, riprap, and curbing were also valued at more than $100,000. Dressed building stone was the only one of these to show decrease in 1916.

PENNSYLVANIA.

The value of granite in Pennsylvania decreased $59,492, or 12 per cent, in 1916. The decrease was chiefly due to dressed monumental, paving, and crushed stone. Building stone increased, owing largely to greater demand in Philadelphia. Operators in general reported high cost of materials and scarcity of labor, which caused curtailment of production and even the closing of quarries.

RHODE ISLAND.

The value of granite sold in Rhode Island in 1916 decreased $60,528, or 9 per cent. This decrease was common to all the important products except dressed monumental stone. Monumental stone continued to be the leading product, followed by crushed stone.

SOUTH CAROLINA.

The value of granite sold in South Carolina in 1916 increased $128,540, or 40 per cent. This increase occurred despite the fact that business was reported dull in the early part of the year and that one company was obliged to shut down two months because of a flood. Prices were reported about the same as in 1915. One feature of the marked increase in demand for South Carolina granite was the establishment of a granite manufacturing center at Columbia, Richland County. The cutting and finishing sheds are directly connected with railway transportation and in 1916 furnished work for between 80 and 90 garnite cutters.[1]

VERMONT.

The value of granite sold by quarrymen in Vermont in 1916 was $2,560,579, a decrease of 8 per cent compared with 1915 and the smallest marketed production reported since 1908. Notwithstanding this decrease, however, Vermont retained first place among the granite-producing States, its value in 1916 representing 15 per cent of the total.

[1] Monumental News, June, 1916, p. 378.

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The State's decrease in 1916 was due to building stone, whose total sales declined 20 per cent in quantity and 39 per cent in value. The average price per cubic foot of rough building stone increased 12 cents, but that of dressed stone decreased 67 cents. The decline in demand for dressed stone was attributed to curtailment of high-class building, owing to present financial conditions and to the difficulty in obtaining structural steel.

Monumental stone (rough and dressed), which represented nearly 89 per cent of the total granite quarried in the State increased about 11 per cent in quantity and 13 per cent in value. The average price per cubic foot of the rough stone increased 4 cents and that of the dressed stone decreased 3 cents.

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Granite sold in Vermont in 1915 and 1916.

County.	Number of active firms reporting.	Building.				Monumental.				Paving.		Other uses.	Total value.
		Rough.		Dressed.		Rough.		Dressed.					
		Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (number of blocks).	Value.	Value.	
1915.													
Orange, Washington, and Windsor.	18	10,776	$7,803	230,169	$1,085,950	1,305,572	$1,263,831	81,771	$306,743	.....	.....	$18,409	$2,681,736
Windham	3	1,255	445	.....	.....	360	228	60	160	34,800	$1,430	27	2,290
Caledonia and Orleans	13	6,139	3,146	1,000	3,000	128,174	70,368	5,450	16,365	.....	.....	1,825	94,704
	34	18,170	11,394	231,169	1,088,950	1,334,106	1,334,427	87,281	322,268	34,800	1,430	20,261	2,778,730
Average price	.....	.....	$0.63	.....	$4.71	.....	$1.00	.....	$3.69	Per M, $41.09		.....	.....
1916.													
Orange, Washington, and Windsor.	22	37,213	$27,980	159,031	$641,927	1,379,919	$1,487,830	82,968	$310,469	.....	.....	17,218	2,480,133
Windham	3	(a)	(a)	.....	.....	(a)	(a)	(a)	(a)	(b) (a)	(b) (a)	(a)	5,286
Caledonia and Orleans	12	4,000	3,000	.....	.....	107,324	59,245	4,500	10,450	.....	.....	2,460	75,155
	37	41,213	30,980	159,031	641,927	1,487,243	1,547,075	87,463	320,919	(b)	(b)	19,728	2,560,579
Average price	.....	.....	$0.75	.....	$4.04	.....	$1.04	.....	$3.66	Per M, $45.24		.....	.....

a Included with Orange, Washington, and Windsor counties.

b Included in "Other uses."

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The figures thus far discussed and the table on page 1030 represent the quarry output, and the dressed stone they include is only that which is manufactured by the quarry owner. Of the total quantity sold by quarry owners in 1916, more than 80 per cent was reported as sold rough. Much of the stone sold rough, however, was finished in independent manufacturing plants in the vicinity of the quarries. This is particularly true of the Barre district, and the following figures, kindly furnished by H. P. Hinman, secretary of the Barre Quarriers & Manufacturers' Association, will give an idea of the extent of the entire granite industry in that district, which includes Barre, Williamstown, East Barre, Montpelier, Waterbury, West Berlin, and Northfield.

Output of Barre granite, 1916.

Total output of rough stock.....cubic feet..	1,560,000
Manufactured in the Barre district.....do.....	1,300,000
Light-stock consumption in district.....do.....	800,000
Dark-stock consumption in district.....do.....	500,000
Number of granite cutters employed (not including unskilled laborers).....	2,550
Average daily wage.....	$4.50
Average number of days worked annually.....	280
Total pay roll for cutters.....	$3,213,000
Overhead.....	1,606,500
Light-stock valuation.....	925,000
Dark-stock valuation.....	670,625
Polished output (not including rough stock).....	900,000
Output from saws.....	212,940
Output from lathes.....	45,000
Gross output.....	7,573,065

VIRGINIA.

The value of granite sold in Virginia in 1916 decreased $417,687, or 48 per cent. This was principally in value of crushed stone for road metal, which declined $379,340, or more than 70 per cent, owing to slackening in road building activity, which was very marked in the two preceding years. Labor was scarce and freight rates were high, one producer reporting that railroad freight rates discriminated in favor of gravel. Keen competition with granite from North Carolina was also reported.

WISCONSIN.

The value of granite sold in Wisconsin in 1916 increased nearly 11 per cent. The State dropped from fourth to fifth place in rank, however, owing to the larger increase in North Carolina. Building stone, a relatively unimportant product, decreased 19 per cent in quantity and 53 per cent in value. The demand was much below normal. The Sauk Rapids Granite Co., however, reported installation of additional machinery valued at $300,000, and stated that its quarry had become the largest quarry of building granite in the West.

Monumental stone, which represented three-eighths of the total value, decreased 2 per cent in quantity but increased 16 per cent in value, its average price per cubic foot gaining 37 cents. Nearly 39 per cent of the monumental stone came from Marathon County

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(Granite Heights, Wausau district); more than 51 per cent in all came from Marinette County (Amberg district) and Marquette County (Montello district).

The value of granite paving blocks, representing 49 per cent of the State's total, increased nearly 8 per cent in quantity and 19 per cent in value. The average price per thousand increased $5.81 in 1916. Waushara County furnished 82 per cent of this product.

The quantity of crushed granite sold in 1916 was practically the same as in 1915, but the value decreased 3 per cent. Scarcity of labor and keen competition with gravel and crushed limestone curtailed the output, but the capacities of some plants were enlarged.

Granite sold in Wisconsin in 1915.

County.	Number of operators.	Building (rough and dressed).		Monumental (rough and dressed).	
		Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.
Green Lake, Jackson, and Waupaca	7	.....	.....	1,065	$1,165
Marathon	4	508	$2,700	46,602	214,699
Marinette	3	15,000	927	31,133	120,837
Waushara and Marquette	8	3,625	3,431	36,033	154,442
	22	19,133	7,058	114,833	491,143
Average price	.....	.....	$0.36	.....	$4.28

County.	Paving blocks.		Crushed stone.		Other.	Total value.
	Quantity (number of blocks).	Value.	Quantity (short tons).	Value.	Value.	
Green Lake, Jackson, and Waupaca	1,301,655	$65,083	94,817	$84,490	$1,686	$152,424
Marathon	.....	.....	.....	.....	263	217,662
Marinette	900	38	.....	.....	260	122,062
Waushara and Marquette	8,927,159	512,637	109,597	87,279	6,914	764,708
	10,229,714	577,758	204,414	171,769	9,123	1,256,851
Average price	Per M, $56.48		.....	$0.84	.....	.....

There were three more producing localities in 1916 than in 1915, but owing to the scattered positions of the deposits worked with relation to the counties and to the varied products reported in each county, it has been necessary to omit the corresponding table for 1916 in order to avoid disclosing individual figures. The following table represents the total output of the State according to uses:

Granite produced in Wisconsin in 1916.

	Quantity.	Value.	Average price.
Building (rough and dressed)..... cubic feet	15,529	$3,236	$0.21
Monumental (rough and dressed)..... do	112,117	521,626	4.65
Paving blocks..... M	11,006	685,622	62.29
Crushed stone..... short tons	208,201	166,752	.81
Other.....	.....	13,640	.....
	.....	1,390,968	.....

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The producing counties were, in order of importance, Waushara, Marathon, Marquette, Marinette, Green Lake, Waupaca, Chippewa, Portage, Shawano, and Forest.

The output of Waushara County was valued at $685,878 (49 per cent of the total), of which $570,888, or 83 per cent, was the value of 9,030,682 paving blocks. Marathon County's production was valued at $248,210, which included as the chief product 43,643 cubic feet of monumental stone valued at $246,672. The greater part of the Marquette County production was monumental stone with paving blocks second. The production of Marinette County was also principally monumental stone, which amounted to 33,500 cubic feet, valued at $119,801, out of a total value of $121,905. Green Lake County produced paving blocks and crushed stone, as did Waupaca County. The other counties produced only crushed stone.

BASALT AND RELATED ROCKS (TRAP ROCK).

This section, entitled "trap rock" in reports prior to that for 1914, includes, besides basalt and diabase, only those dark igneous rocks that are very similar to basalt and diabase in mineral and chemical composition and in physical properties. A small production reported by operators who regard the term "trap rock" as synonymous for crushed stone may be wrongly included in this section, but if so it is only an insignificant fraction of the total.

The year 1916 was marked by the second decrease in marketed production of basalt and related rocks since 1908. The first of these decreases (14 per cent), recorded in 1914, was partly compensated by a gain of 8 per cent in 1915, but was followed by a decline of nearly 10 per cent ($823,925) in 1916, which brought the total value to the lowest figure since 1912, as is shown in the following table:

Value of basalt and related rocks (trap rock) sold in the United States, 1912–1916.

State or Territory.	1912	1913	1914	1915	1916
Arkansas	(a)	(a)	$233,987	$147,442	$185,360
California	$1,926,347	$2,132,245	1,589,321	1,136,589	988,140
Colorado				(b)	(b)
Connecticut	581,070	713,323	549,156	696,744	788,661
Hawaii	231,351	249,390	88,417	195,500	381,771
Idaho					(b)
Massachusetts	915,241	1,194,068	691,330	632,989	647,044
Michigan	36,206	92,201	34,406	105,355	83,072
Minnesota	(a)	147,306	77,338	80,640	130,868
New Jersey	1,202,397	1,359,981	1,164,529	1,281,545	1,208,217
New York	831,667	1,077,690	895,147	762,370	956,100
Oregon	260,767	316,007	397,824	739,380	303,909
Pennsylvania	916,383	1,218,918	1,076,001	1,101,778	1,041,208
Texas			(a)	(b)	(b)
Washington	668,630	632,915	1,068,042	1,452,369	754,831
Wisconsin	(a)	(a)	(a)	(b)	(b)
Undistributed				153,521	162,126
	7,560,049	9,134,494	7,865,998	8,489,222	7,666,297

a Included under granite.

b Included in "Undistributed."

Of the 16 producing States, however, 9 showed increase in value in 1916. The principal gains were made by Hawaii (95 per cent) and New York (25 per cent); the greatest losses by Oregon (59 per cent), Washington (48 per cent), and California (17 per cent), where general

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declines in demand were reported. The last two States fell below the $1,000,000 mark, leaving only New Jersey and Pennsylvania above it. In contrast to this great general decline in the Pacific Coast States, the Eastern States, except Pennsylvania, showed small gains. Demand in the Eastern States was better on the whole than in 1915, but increased costs, scarcity of labor, and transportation difficulties both reduced profits and curtailed output. Local poor demands were due more to scarcity of labor for railroad maintenance and improvement and other projects, although a few producers reported smaller output, owing to competition with gravel and (in Pennsylvania) with furnace slag. In the north central region, Michigan's reduced output was attributed to high cost of operating and to scarcity of labor, and Minnesota's increase was due to marked improvement in demand, which caused a substantial gain in value in spite of reduced price. In Texas, reduced output of basaltic rock as well as of crushed granite was attributed to a large increase in freight rates by the Interstate Commerce Commission ("Shreveport decision") and to inability to compete with other materials.

Value of basalt and related rocks (trap rock) sold in the United States in 1915 and 1916.

State or Territory.	Building.	Riprap and rubble.	Paving.	Crushed stone.			Other.	Total.
				Road metal.	Railroad ballast.	Concrete.		
1915.								
Arkansas	.....	$6,703	.....	$50,444	$34,337	$55,958	.....	$147,442
California	$2,128	62,029	$109,197	375,896	78,052	490,057	$19,230	1,136,589
Colorado	.....	.....	.....	.....	.....	.....	.....	(a)
Connecticut	14,373	4,275	1,530	328,715	131,055	217,217	1,579	698,744
Hawaii	.....	76,958	.....	36,366	15,000	67,176	.....	195,500
Massachusetts	12,709	1,000	.....	423,548	70,686	123,586	1,460	632,989
Michigan	.....	54,000	.....	29,764	44	22,047	.....	105,855
Minnesota	.....	4,515	.....	11,305	.....	64,820	.....	80,640
New Jersey	1,547	2,056	18,033	752,960	221,579	284,731	639	1,281,545
New York	2,250	.....	.....	459,440	70,640	230,040	.....	762,370
Oregon	9,352	285,053	2,200	202,580	80,433	151,399	8,363	739,380
Pennsylvania	9,898	10,868	1,703	406,949	474,484	195,257	619	1,101,778
Texas	.....	.....	.....	.....	.....	.....	.....	(a)
Washington	50	1,353,367	3,397	93,167	2,388	500	.....	1,452,869
Wisconsin	.....	.....	.....	.....	.....	.....	.....	(a)
Undistributed	.....	.....	10,500	42,973	16,175	83,373	.....	153,521
	52,307	1,860,824	146,560	3,216,107	1,194,873	1,986,661	31,890	8,489,222
1916.								
Arkansas	(a)	(a)	.....	(a)	(a)	(a)	.....	185,360
California	.....	28,300	34,694	294,846	74,996	503,038	2,266	938,140
Colorado	.....	.....	(a)	(a)	.....	.....	.....	(a)
Connecticut[b]	13,453	.....	.....	333,228	45,856	395,064	.....	788,661
Hawaii	(a)	(a)	.....	72,673	.....	151,132	4,830	381,771
Idaho	.....	.....	.....	.....	.....	(a)	.....	(a)
Massachusetts	18,178	.....	.....	425,363	9,600	192,453	1,450	647,044
Michigan	.....	(a)	.....	37,475	(a)	9,715	847	83,072
Minnesota	(a)	(a)	.....	19,200	.....	107,034	.....	130,863
New Jersey	6,538	9,721	7,685	796,929	165,339	295,005	12,000	1,293,217
New York[b]	.....	.....	.....	414,200	45,200	492,700	.....	956,100
Oregon	5,564	56,882	.....	156,414	8,787	68,522	.....	303,909
Pennsylvania	4,987	11,468	(a)	452,558	357,277	212,002	722	1,041,203
Texas	.....	.....	.....	(a)	(a)	(a)	.....	(a)
Washington[b]	.....	680,996	.....	71,210	.....	.....	.....	754,831
Wisconsin	.....	.....	.....	(a)	(a)	(a)	.....	(a)
Undistributed	15,557	195,172	15,239	118,528	54,265	158,399	740	162,126
	64,277	982,539	57,618	3,192,624	761,320	2,585,064	22,855	7,666,297

[a] Included in "Undistributed."
[b] Small values not enumerated included in "Undistributed."

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Crushed stone, as shown in the table above, represented by far the greater part of the total value and made a net gain of $141,367, or 2 per cent, in 1916. This gain was due to an increase of $598,403 (30 per cent) in value of crushed stone for concrete, which more than offset declines in stone for railroad ballast of $433,553 (36 per cent) and in stone for road metal of $23,483 (less than 1 per cent). The average price per ton in 1916 was 73 cents, a gain of 8 cents over 1915. The quantities of crushed stone sold in 1916 were 4,268,000 short tons for road metal, 1,101,958 short tons for railroad ballast, and 3,638,416 short tons for concrete. Compared with 1915, there was a decrease of 10 per cent in quantity for road metal, a decrease of 43 per cent in quantity for railroad ballast, and an increase of 20 per cent in quantity for concrete. The total quantity decreased 8 per cent. Building stone, representing less than 1 per cent of the total value, also increased in 1916. The greatest decline ($878,285, or 47 per cent) was in the value of stone for riprap and rubble, used principally in the Pacific Coast States for harbor improvement work, which largely ceased in Washington and Oregon in 1916.

Paving blocks of diabase and basalt, after a considerable increase in 1915, decreased in 1916—58 per cent in quantity, 61 per cent in value, and $2.55 in average price per thousand. In California, the only State in which they had previously been important, they declined to comparative insignificance, although even in 1916 they exceeded granite paving in that State by 241,000 blocks. In no other State did sales in 1916 exceed $10,000 in value. The decline in paving stone in California was attributed by one producer to substitution of vitrified brick. No information is at hand regarding specifications for cutting and laying basalt paving blocks, but there is no reason to doubt that if cut and laid according to the standard specifications for granite blocks they will offer maximum resistance to wear in streets of very heavy traffic.

Paving blocks of basalt and related rocks (trap rock) sold in the United States in 1915 and 1916.

State.	1915		1916	
	Number.	Value.	Number.	Value.
California	2,689,219	$109,197	797,000	$34,694
Colorado	140,000	10,500	(a)	(a)
Connecticut	38,250	1,530	(a)	(a)
New Jersey	479,400	18,033	301,260	7,685
Oregon	60,000	2,200	(a)	(a)
Pennsylvania	39,600	1,708	(a)	(a)
Washington	133,233	3,397	(a)	(a)
Undistributed			402,435	15,239
	3,579,702	146,560	1,500,695	57,618
Average price per thousand		$40.94		$38.39

a Included in "Undistributed."

In Hawaii the value of stone for "other" purposes mostly represented monumental stone, the remainder representing ship ballast.

A few further inquiries have been received recently regarding vesicular basalt for paper-making machinery. This stone, formerly imported from Germany, was described in the stone report for 1914.

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Inquiries sent out by the Survey resulted in the location of satisfactory material in the State of Washington, and it is expected that the occasional demands for small quantities of the stone can now be satisfied.

MARBLE.

MARKETED PRODUCTION.

The figures for marketed production of marble here presented include for some States the value of serpentine (verde antique) and "onyx marble." These products are considered separately on pages 1039–1040.

Owing to the small number of producers in many of the marble-producing States, it is not possible to compile a satisfactory table showing the production by States. The figures are given, however, as far as they are available.

In 1916 the commercial output of marble came from the following States, arranged according to value of output:

Vermont: Addison, Bennington, Franklin, Grand Isle, Rutland, and Washington counties.
Tennessee: Blount, Hawkins, Knox, Loudon, and Union counties.
Georgia: Cherokee and Pickens counties.
Alaska: Tokeen, Ketchikan mining district, southeastern Alaska.
Colorado: Gunnison County.
New York: Clinton, Dutchess, St. Lawrence, Warren, and Westchester counties.
Alabama: Talladega County.
Missouri: Green and Jasper Counties.
Massachusetts: Berkshire and Hampden counties.
Utah: Utah County.
California: Inyo, Los Angeles, Tulare, and Tuolumne counties.
Maryland: Baltimore and Harford counties.
North Carolina: Cherokee County.
Pennsylvania: Chester, Montgomery, and Northampton counties.
Arkansas: Independence County.
Texas: San Saba County.
South Carolina: Oconee County.
New Mexico: Otero County.
Washington: Stevens County.

Quarries in Kentucky, Virginia, and Oregon, which furnished small quantities in 1915, reported no production in 1916.

The value of marble sold in 1916, according to reports from 80 active producers, was $7,033,171. This was an increase of nearly 2 per cent compared with 1915, but was less than the value of any of the four preceding years. Marble was the only kind of stone besides limestone to show increased value in 1916. The increase, according to the table below, was mainly due to Vermont, New York, Pennsylvania, and Tennessee, all of which, except Pennsylvania, showed marked decrease in 1915. The gain of these States was more than sufficient to offset losses by Georgia, Missouri, and other States, included under "Undistributed." The increase of 2 per cent in a year characterized by such poor demand for high-class building is far from discouraging.

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Value of marble sold in the United States, 1912–1916.

State or Territory.	1912	1913	1914	1915	1916
Alabama	(a)	(a)	$370,766	(a)	(a)
Alaska	(a)	(a)	(a)	(a)	(a)
Arkansas	(a)	(a)	(a)	(a)	(a)
California	876,424	872,768	70,451	847,976	862,397
Colorado	(a)	(a)	(a)	(a)	(a)
Georgia	1,096,622	1,101,997	1,190,742	973,605	908,843
Kentucky	(a)		(a)	(a)	
Maryland	(a)	(a)	(a)	(a)	(b)
Massachusetts	213,939	276,819	206,883	223,208	154,090
Missouri	(c)	(b)	(a)	122,238	156,942
New Mexico	(a)	(a)	(a)	(a)	(a)
New York	291,210	252,982	248,787	202,843	268,391
North Carolina	(a)	(a)	(a)	(a)	(a)
Oregon		(a)		(a)	
Pennsylvania	267,242	(a)	(a)	60,819	c 107,212
South Carolina				(a)	(a)
Tennessee	974,733	1,416,952	1,253,549	959,037	1,000,266
Texas			(a)	(a)	(a)
Utah	(a)	(a)	(a)	(a)	(a)
Vermont	3,494,253	3,513,405	3,490,971	2,792,764	3,062,743
Virginia	(d)	(a)	(a)	(a)	
Washington		(a)	(a)		(a)
Undistributed	1,372,035	1,235,967	1,289,263	1,533,540	1,317,787
	7,786,458	7,870,890	8,121,412	6,916,025	7,083,171

a Included in "Undistributed."
b Included in Pennsylvania.
c Includes Maryland.
d Included in limestone.

Most quarrymen report their output from year to year in the same units, mostly the cubic foot, so that the following comparison both of the quantities sold annually by the cubic foot or the square foot or the ton and also of their corresponding values is possible.

Marble sold in the United States, 1914–1916.

		1914		1915		1916	
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Rough:							
Monumental	cubic feet	814,905	$1,168,493	732,272	$1,005,068	743,640	$1,094,205
Building, exterior	cubic feet	713,283	913,247	684,224	802,377	484,456	633,010
	short tons	82,679	26,909	5,000	3,900	6,498	7,646
	square feet	3,000	840				
Building, interior	cubic feet	847,767	1,317,538	697,997	1,133,366	1,014,442	1,571,781
	short tons	2,300	805	2,300	805	2,300	805
	square feet	640	616			(a)	(a)
Dressed:							
Monumental	cubic feet	241,229	1,134,991	192,445	868,600	197,441	965,205
Building, exterior	square feet					(a)	(a)
	cubic feet	343,592	1,207,274	367,201	1,213,964	276,792	816,113
Building, interior	cubic feet	433,766	2,080,660	395,512	1,695,059	389,110	1,697,028
	square feet	250	375	10,000	15,000	(a)	(a)
Ornamental	cubic feet	1,700	20,200	1,650	19,950	(a)	(a)
Other uses	cubic feet	65,755	102,393	3,810	476	3,700	25,400
	short tons	159,228	144,864	157,533	156,864	135,901	183,755
	square feet	46,228	2,177	19,592	596	8,179	18,223
Total	cubic feet	3,461,997	7,942,826	3,075,211	6,738,860	3,109,581	6,822,742
	short tons	194,207	172,578	164,833	161,569	145,699	192,206
	square feet	50,127	4,008	29,592	15,596	8,179	18,223
			8,121,412		6,916,025		7,083,171

a Included under other uses.

According to this table, the quantity and value of monumental stone, after considerable declines in 1914 and 1915, made a small increase in 1916. Rough marble for this work increased about 2 per cent in quantity and about 8 per cent in value, and dressed

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marble increased about 3 per cent in quantity and 13 per cent in value. With three exceptions (1909, 1911, and 1915), however, the total quantity and value of monumental marble in 1916 was less than in any year since 1903. Rough stone continued to represent a little more than one-half of the total value.

The total value of building stone made a small decrease, following a much larger decrease in 1915, and was less than in any year since 1910. Rough stone for exterior building decreased 29 per cent in quantity and 21 per cent in value in 1916. It reached its maximum value in 1911, decreased abruptly in the two following years, then decreased gradually, and fell to $640,656 in 1916. Rough marble for interior building, after a decrease in 1915, made a substantial gain (39 per cent) in value in 1916 and showed the greatest quantity and value since 1913, when figures for this class of marble were first separately recorded. Dressed marble for exterior building decreased markedly in quantity (25 per cent) and value (33 per cent) in 1916 and fell below the previous low record of 1913. This class of marble, after a marked continuous increase in value from 1904 to 1908, has fluctuated but has on the whole declined since then. Dressed marble for interior building remained about the same in quantity and value in 1916 as in 1915. It also showed a marked increase from 1903 to 1908, and since then has fluctuated, showing neither marked net gain nor loss. Rough building marble as a whole gained in 1916, and the dressed stone declined. Exterior stone as a whole decreased markedly and interior stone made a moderate gain.

Marble for ornamental and "other" uses declined in quantity but increased in value in 1916. That for "other" uses includes rough stone sold to lime burners, to carbonic acid factories, to pulp mills, and to iron furnaces for flux; that used for making roads; and the dressed stone sold for terrazzo, mosaics, and electrical work. Stone sold for terrazzo in 1916 amounted to 24,340 short tons, valued at $83,466.

A novel use of marble for electric-light shades is described as follows:[1]

> Marble cut into thin slices ranging from a tenth of an inch to a quarter of an inch in thickness is now being used for electric-light shades, both in homes and public buildings. It gives a softer light than the opalescent glass which it is replacing. The amount of light transmitted is about equal, but the diffusive power of marble is greater. The effect of the heat upon the marble gives it a slight glow, causing the delicate natural veinings to show up with beautiful effect. Marble is not affected by sudden changes of temperature and hence is more durable than glass.

The so-called marble, really a soapstone, on Catalina Island has proved the most satisfactory material for use as a high-voltage insulator in the Cottrell process for extracting potash from the flue dust of cement plants.[2] Ordinary marble, as well as glazed porcelain insulators, are reported not able to stand the temperature, which ranges from atmospheric to 1,200° F. (650° C.).

The table below, giving the marble sold in different States, shows, as usual, great differences in the ratio of quantity to value. These differences are due to the fact that much of the marble in some States, as Vermont, was sold in the finished condition by the producers, whereas that in other States, as Georgia, was sold rough.

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[1] The Reporter, April, 1916, p. 27.
[2] Hewitt, A. C., Potash becomes a valuable cement-mill by-product: Eng. News, vol. 76, p. 1222, Dec. 28, 1916.

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Marble sold in California, Georgia, Massachusetts, Missouri, New York, Tennessee, and Vermont in 1915 and 1916.

State.	1915			1916		
	Quantity.	Value.	Average price.	Quantity.	Value.	Average price.
California:						
Short tons	630	$4,110	$6.52	10,360	$14,800	$1.43
Cubic feet	24,131	43,866	1.82	21,909	47,597	2.17
	.....	47,976	.....	.....	62,397	.....
Georgia:						
Short tons	22,200	39,300	1.77	22,000	47,000	2.13
Cubic feet	848,633	934,305	1.10	702,537	856,343	1.22
	.....	973,605	.....	.....	903,343	.....
Massachusetts:						
Short tons	12,590	20,056	1.59	16,103	24,864	1.54
Cubic feet	100,879	203,147	2.01	67,735	129,226	1.91
	.....	223,203	.....	.....	154,090	.....
Missouri:						
Cubic feet	131,522	121,642	.92	143,141	156,942	1.10
Square feet	19,592	596	.03	.....	.....	.....
	.....	122,238	.....	.....	156,942	.....
New York:						
Short tons	59,603	53,149	.89	50,146	59,566	1.19
Cubic feet	97,949	149,694	1.53	119,311	208,825	1.75
	.....	202,843	.....	.....	268,391	.....
Tennessee:						
Cubic feet	535,929	959,087	1.79	563,609	1,000,266	1.77
	.....	959,087	.....	.....	1,000,266	.....
Vermont:						
Short tons	6,900	4,385	.63	6,900	4,385	.63
Cubic feet	870,656	2,788,379	3.20	935,321	3,058,358	3.27
	.....	2,792,764	.....	.....	3,062,743	.....

SERPENTINE (VERDE ANTIQUE).

The serpentine classed as marble in this report is that variety which, from its use as ornamental stone, answers the purpose of marble. A small quantity was formerly quarried for building stone, but no sales for this use were reported in 1915 or 1916. Sales in 1916, reported from the following six States, arranged according to value: Vermont, Pennsylvania, Maryland, Massachusetts, Georgia, and California, one producer reporting from each State. The following table shows a decrease of 26 per cent in value of total sales in 1916:

Serpentine produced and sold in the United States in 1915 and 1916.

Year.	Quantity.	Value.
1915: Cubic feet	46,126	$183,544
Square feet	10,000	15,000
Tons	2,765	5,648
		204,192
1916: Cubic feet	28,709	124,072
Square feet	8,179	18,223
Tons	3,437	7,492
		149,787

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A small quantity of serpentine is worked in California as a source of magnesia for refractory purposes. This production is included in the annual report on magnesite, from which most of the magnesia for refractory and other purposes is obtained. Some experimental work on the extraction of magnesia from serpentine for other than refractory purposes is also under way.

ONYX MARBLE.

No sales of "onyx" marble were reported in 1916. Sales in 1915, amounting to 4,574 cubic feet, valued at $19,270, were reported from Utah, Kentucky, and New Mexico.

MARBLE INDUSTRY BY STATES.

ALABAMA.

Alabama's output of marble in 1916 was mainly dressed stone for interior building. Trade conditions were reported much worse than in 1915, which in turn was somewhat poorer than in 1914. The Madras Marble Co., of Sylacauga, reported the opening of a new quarry.

ALASKA.

Alaska's output in 1916 was entirely rough stone for interior building. Sales of Alaskan marble have been reported annually since 1904 and have shown an almost steady increase in value. The increase in 1916 was the most marked and raised Alaska to fourth place among the marble-producing States in spite of the fact that one company was compelled to suspend operations because of prohibitive freight rates and scarcity of ships.

CALIFORNIA.

The greater part of California's production of marble is rough stone for interior building. The value of its marketed production in 1916 was about one-fifth greater than in 1915, though some reports indicated that business was poorer. The value of California marble increased on the whole from 1901 to 1907 but since then has prevailingly decreased, the value for 1916 being only about two-sevenths of the record value in 1907. A report by W. B. Tucker [1] on the marble deposits of Tuolumne County, in which the quarries of the Columbia Marble Co. are located, was issued in 1915.

COLORADO.

More than half of Colorado's production of marble in 1916 was sold dressed for exterior building, less than one-fourth went as dressed stone for interior building, and about one-eighth went as dressed monumental stone. Colorado's marketed production, after a decrease in 1913, rose to a maximum value in 1915 and again decreased in 1916. The Colorado Yule Marble Co., the most prominent marble producer of the State, went into receiver's hands during the year. The Villa Grove Marble & Onyx Co., Villa Grove, Saguache County,

[1] Tucker, W. B., Mines and mineral resources of Amador County, Calaveras County, Tuolumne County: California State Min. Bur. Rept., 1913-14, pp. 169-172, 1915.

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reported that it was opening a quarry of onyx marbles of mahogany-red, yellow, green, dove, blue, and chocolate colors, and would be ready to begin shipment of the red varieties in the spring of 1917.

GEORGIA.

Rough marble for exterior building and for monumental work, sold in Georgia in 1916, had about equal values. Rough marble for interior building was next in importance. The demand for certain of the high-grade interior marbles was reported to be poor in 1916. The total value decreased 7 per cent, and Georgia dropped from second to third place among the marble-producing States.

MARYLAND AND PENNSYLVANIA.

The marketed production of Maryland and Pennsylvania combined amounted in 1916 to 36,646 cubic feet, 8,179 square feet, and 13,680 tons, valued at $107,212. Five quarries were active, including three of serpentine (verde antique). No special comments on conditions of the industry were made by producers.

MASSACHUSETTS.

Marble in Massachusetts was mostly sold dressed for interior and exterior building and for monumental work in 1916. Considerable rough stone for exterior and interior work was also sold. Sales in 1916 decreased to $154,090, following a small increase in 1915. One producer reported poor demand, owing to increased use of concrete. The output of Massachusetts has on the whole remained stationary since 1900. In no year since 1901 has the total value been less than $150,000 and in only two years, 1906 and 1913, has it exceeded $250,000.

MICHIGAN.

Development work continued at Ishpeming on the property of the Michigan Verde Antique Marble Co., which reported that shipments would be made in 1917. This deposit is on the site of the old Ropes gold mine, which was worked about 1880. Occasionally efforts to develop this deposit of serpentine, or verde antique, were made since its discovery by Julius Ropes in 1877, but were conducted by individuals ignorant of marble working and ended in disappointment.[1]

The present development is being conducted according to modern methods and success has been predicted, although the beginning of shipments comes at a most unfavorable time for the marketing of this kind of stone. The deposit is said to contain the following varieties: Verde antique, green base with a clearly marked network of markings of various shades of green; green marble breccia, in which the colors are well blended; red spotted green antique, dark-green ground marked with small red and black spots; and rouge antique or rosso antico, in which scarlet and blood-red shades are separated by parallel layers of white and in places are intersected by networks of black veinlets.

[1] The Reporter, January, 1916, pp. 25–26.

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Prospecting was reported on the property of the Marquette Green Marble Co., about a mile south of the property just mentioned.[1] It has been reported that arrangements have been made for extending a spur from the Chicago & North Western Railway to this property and that of the Michigan Verde Antique Marble Co.

MISSOURI.

By far the greater part of Missouri's production of marble sold in 1916 was building stone, rough and dressed, for interior work. A considerable quantity was also sold rough for exterior building. The marbles of Missouri are quarried in the Phenix and Carthage districts. In the Carthage district the distinction between marble and limestone is somewhat arbitrary. Much of the stone fulfills the requirements for commercial marble, and much that does not satisfy these requirements nevertheless affords excellent building material. The total marketed production of limestone and marble in Missouri in 1915 and 1916 is shown on page 1039. Marble alone made a substantial increase in quantity and value in 1916.

MONTANA.

Discovery of an unusual marble 3½ miles southeast of Livingstone, Mont., has been reported. Owing to its strong resemblance to mahogany, it has been named mahogany marble.[2]

NEW MEXICO.

A small production of dressed marble for monumental work at Alamagordo was reported from New Mexico in 1916. Another deposit in this district has been reported, but no definite plans to develop it have been made.

NEW YORK.

New York's total quantity and value of marble sold increased $65,548, or 32 per cent, in 1916. Rough monumental and dressed exterior building stone were the leading products, followed by rough stone for exterior and interior building. Waste from one of the idle Tuckahoe quarries was used for making artificial stone. In April 1916, the Gouverneur Marble Co. took over the properties of the Northern New York Marble Co. and the Empire Marble Co. The opening of a new quarry on the Empire property was reported. This property has furnished some of the darkest and most valuable marble discovered in the Gouverneur district.[3]

NORTH CAROLINA AND SOUTH CAROLINA.

One company each in North Carolina and South Carolina was active in 1916. Their main product was dressed monumental stone.

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[1] Stone, September, 1916, p. 479.
[2] Stone, July, 1916, p. 317.
[3] Stone, October, 1916, p. 526.

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TENNESSEE.

Tennessee's marketed production increased in quantity (5 per cent) and value (4 per cent) in 1916, and the State regained second place among marble-producing States, which it lost to Georgia in 1915. The total cubic feet sold, however, were far less than in 1912, 1913, or 1914, and the value less than in 1913 and 1914. Most of the producers reported a poor market, some a worse one than in 1915, as erection of large buildings was delayed, owing to shortage of structural steel and to increased costs of production. Shortage of fuel, also, curtailed the output of some companies. About half of the total value in 1916 was represented by dressed interior building stone, and rough interior building stone was second in importance.

In Blount County the Quaker Marble Co. opened and equipped a new quarry during the year. In Granger County the Richland Marble Co. began quarrying and produced a considerable quantity of stone. The Tennessee Marble Corporation reported that it would begin production in 1917 from its quarry at Newhart Springs, near Knoxville, in Knox County. In Lincoln County a quarry owned by the Brighton Marble & Development Co., at Flintville, was also reported ready to market stone in 1917, provided a spur track 2 miles long could be built.

TEXAS.

Two companies were active in the San Saba district of Texas. Their output was rough stone, mainly for building.

UTAH.

The Mount Nebo Marble Co. reported sales in 1916, mainly of dressed interior building stone. This stone was mostly for the new office building of the Mormon Church at Salt Lake City. Red golden travis was used for columns and light golden travis for floor work.[1] The Mount Nebo Marble Co. produced a considerable quantity of "onyx marble" during development work in its quarry at Low, Tooele County.

VERMONT.

Vermont's marketed production in 1916 represented more than 43 per cent of the total value of marble sold, and showed an increase of more than 7 per cent in quantity and of nearly 10 per cent in value over 1915. With the exception of 1915, however, the figures for 1916 were less than in any year since 1903. The marketed products in 1916 ranged as follows in order of value: Dressed monumental stone, dressed interior building stone, rough monumental stone, dressed exterior building stone, rough interior building stone, rough exterior building stone, ornamental stone, and "other" stone. Rough monumental stone ranked first in quantity, followed by dressed exterior building stone, dressed monumental stone, rough interior building stone, dressed interior and rough exterior building stone.

[1] Stone, May, 1916, p. 260.

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The Meadowbrook Marble Co. opened a quarry at Brandon, Vt. and considered plans for erecting a mill. The Middlebury Marble Co. completed a modern crushing and screening plant with a capacity of 30 tons a day for the manufacture of white terrazzo from the waste from its white marble beds. This marble, because of its hardness, is said to make terrazzo of unusual wearing qualities.[1]

The Vermont Marble Co.'s output was curtailed to some extent by the destruction of its large "Palace" mill at Rutland.

LIMESTONE.

GENERAL STATISTICS.

The value of limestone sold in 1916, as shown in the accompanying table, was greater by $6,090,005, or 17 per cent, than in 1915, which had increased 4 per cent over the value in 1914. Gains were made in 28 States whose values are shown separately. The most conspicuous gain was in Pennsylvania, where the increase was more than $1,800,000, following an increase of more than $1,000,000 in 1915. Michigan increased more than $370,000 in 1915 and more than $500,000 in 1916; Ohio nearly $275,000 in 1915 and more than $900,000 in 1916. Several States showed record values in 1916, and 11 States had outputs valued in excess of $1,000,000, compared with 8 in 1915. Only five States, the values of whose productions are separately published, showed decrease in 1916. These were California, Georgia, Tennessee, Texas, and Virginia. That four of the five were Southern States is rather striking. States with values exceeding $2,000,000 were, in order of rank, Pennsylvania, Ohio, Indiana, Illinois, New York, and Michigan. Pennsylvania's value in 1916 was almost 20 per cent of the total, compared with 18 per cent in 1915 and 16 per cent in 1914. Nearly seven-eighths of it was represented by furnace flux, and the rest chiefly by crushed stone, which exceeded $1,000,000 in value. Ohio's value in 1916 was 13 per cent of the total, compared with 12 per cent in both 1914 and 1915. In 1916, crushed stone was Ohio's leading product and represented more than $3,000,000, or nearly 57 per cent of the State's total, and furnace flux was second, valued at more than $1,600,000, or about 32 per cent of the total.

[1] Stone, October, 1916, p. 538.

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Value of limestone produced and sold in the United States, 1912 to 1916.

State.	1912	1913	1914	1915	1916
Alabama	$531,085	$812,664	$737,214	$426,266	$917,559
Arizona	19,099	6,328	(a)	9,800	98,877
Arkansas	66,952	52,220	47,390	32,917	64,809
California	245,235	323,287	286,273	338,179	277,521
Colorado	365,004	428,736	340,059	337,899	406,974
Connecticut	17,924	(a)	(a)	26,246	(a)
Florida	60,524	156,589	343,779	354,673	479,837
Georgia	53,187	83,899	89,216	86,254	82,799
Hawaii				(a)	(a)
Idaho	19,791	18,569	28,032	(a)	27,721
Illinois	3,806,784	4,112,172	2,861,340	2,864,103	3,362,751
Indiana	5,066,337	4,649,597	4,115,557	4,204,092	4,657,813
Iowa	944,885	803,682	537,362	535,656	561,015
Kansas	757,197	824,005	598,302	535,240	599,995
Kentucky	1,160,148	1,069,034	1,196,046	993,388	1,288,974
Louisiana	(a)	(a)	(a)	(a)	(a)
Maine	(a)	(a)	(a)		
Maryland	228,713	282,241	204,276	180,723	223,182
Massachusetts	(a)	(a)	(a)	(a)	(a)
Michigan	1,139,560	1,408,708	1,457,961	1,828,766	2,389,763
Minnesota	546,650	636,620	489,849	395,763	467,942
Missouri	2,373,725	2,486,020	2,160,958	1,927,534	1,990,419
Montana	154,133	260,915	207,821	228,637	237,923
Nebraska	335,369	326,287	302,862	320,341	405,867
Nevada	(a)				
New Jersey	205,334	280,680	240,937	159,549	245,019
New Mexico	237,543	148,266		(a)	(a)
New York	3,208,911	3,539,043	3,158,617	3,018,871	3,085,786
North Carolina	39,864	67,132	58,754	82,672	87,418
Ohio	4,885,088	4,945,310	4,131,917	4,405,590	5,337,085
Oklahoma	409,994	246,912	237,044	398,636	516,230
Oregon	(a)	(a)	(a)	(a)	(a)
Pennsylvania	6,017,308	6,189,145	5,270,458	6,367,446	8,167,639
Rhode Island	(a)	(a)	(a)	(a)	(a)
South Carolina				(a)	
South Dakota	10,628	4,098	12,488	17,485	19,435
Tennessee	673,329	643,586	678,068	855,245	752,649
Texas	530,251	590,289	549,567	492,255	459,918
Utah	208,245	368,007	303,081	196,271	249,998
Vermont	12,644	17,715	24,049	49,405	68,098
Virginia	403,069	598,032	1,194,261	1,534,545	1,087,247
Washington	20,370	62,913	10,008	11,550	30,338
West Virginia	981,467	1,046,625	778,749	922,766	1,452,393
Wisconsin	853,477	1,017,135	1,007,106	894,158	1,089,111
Wyoming	64,749	108,234	50,500	(a)	(a)
Undistributed	73,227	130,734	134,254	196,945	179,766
	36,729,800	38,745,429	33,894,155	35,229,866	41,319,871

a Included in "Undistributed."

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Value of limestone sold in the United States in 1915 and 1916.

1915.

	Rough building.	Dressed building.	Paving.	Curbing.	Flagging.	Rubble.	Riprap.
Alabama	$6,912	$15,487				$800	$18,379
Arizona							7,800
Arkansas	64					244	660
California	3,500						
Colorado							
Connecticut						1,336	
Florida	15,000	70,000					2,438
Georgia	200						
Hawaii[a]							
Idaho[a]							
Illinois	8,259	5,400	$1,292	$175	$60	47,717	225,454
Indiana	1,011,860	1,935,367	8	64,026	2,522	17,338	16,741
Iowa	28,949	3,716	9,015	25	140	13,882	92,182
Kansas	19,621	14,198	1,357	526	86	16,554	48,090
Kentucky	66,373	47,134	400	4,782	536	2,925	34,083
Louisiana[a]							
Maryland	3,930						
Massachusetts[a]							
Michigan	4,262		200			743	104
Minnesota	34,738	80,937			140	22,198	58,697
Missouri	60,203	337,004	800	210	2,529	132,458	323,918
Montana	6,298		2,606			60	55
Nebraska	2,319					800	54,456
New Jersey	275						225
New Mexico[a]							
New York	50,040	17,644	392	1,457	550	2,084	2,929
North Carolina							
Ohio	59,725	2,733				848	66,170
Oklahoma	501	743		500		228	29,196
Oregon[a]							
Pennsylvania	49,150	695	1,826	28	105	4,637	2,057
Rhode Island[a]							
South Carolina[a]							
South Dakota							8,875
Tennessee	166					2,324	187,447
Texas	18,191	32,169		135		576	28,431
Utah	2,700	320					
Vermont	1,095					1,000	
Virginia	1,400	1,018				200	6,160
Washington	997						
West Virginia						1,500	
Wisconsin	31,917	2,691	1,800	8,551	1,060	35,664	76,470
Wyoming[a]							
Undistributed	300						14,619
	1,488,945	2,567,256	19,396	80,415	7,758	306,116	1,305,636

[a] Included in "Undistributed."

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Value of limestone sold in the United States in 1915 and 1916—Continued.

1915—Continued.

	Crushed stone.			Flux.	Sugar factories.	Agricultural.	Other.	Total value.
	Road metal.	Railroad ballast.	Concrete.					
Alabama	$42,116	$554	$45,443	$289,167	.....	$7,386	$22	$426,266
Arizona	.....	.....	.....	1,330	$570	.....	100	9,900
Arkansas	9,600	3,756	13,800	38	.....	4,717	38	32,917
California	78,970	17,708	27,180	70,087	120,965	11,519	8,255	338,179
Colorado	.....	.....	.....	272,093	63,027	.....	2,779	337,899
Connecticut	160	.....	1,442	1,675	.....	21,633	.....	26,246
Florida	56,381	50,000	108,003	.....	.....	52,851	.....	354,673
Georgia	23,000	.....	16,600	3,453	.....	39,751	3,250	86,254
Hawaii	.....	.....	.....	.....	.....	.....	.....	(a)
Idaho	.....	.....	.....	.....	.....	.....	.....	(a)
Illinois	706,405	341,126	1,072,180	348,547	.....	82,450	25,038	2,864,108
Indiana	910,462	55,649	33,262	69,834	11,706	36,908	38,409	4,204,092
Iowa	28,315	78,886	261,541	2,905	141	15,907	52	535,656
Kansas	15,591	109,117	222,524	533	.....	1,144	25,899	535,248
Kentucky	379,234	327,578	78,652	19,259	.....	31,303	1,129	993,388
Louisiana	.....	.....	.....	.....	.....	.....	.....	(a)
Maryland	78,865	31,367	63,152	2,059	.....	200	1,150	180,723
Massachusetts	.....	.....	.....	.....	.....	.....	.....	(a)
Michigan	194,970	19,640	217,304	763,029	46,143	9,746	572,625	1,823,766
Minnesota	4,218	.....	177,093	664	2,100	970	14,008	395,763
Missouri	378,086	82,005	513,763	26,591	5,577	4,841	59,549	1,927,534
Montana	5,186	178	8,303	189,576	16,375	.....	.....	228,637
Nebraska	.....	11,913	249,269	.....	1,584	.....	.....	320,341
New Jersey	8,994	750	5,462	141,915	.....	1,598	330	159,549
New Mexico	.....	.....	.....	.....	.....	.....	.....	(a)
New York	1,077,018	614,875	599,302	416,712	.....	99,553	136,315	3,018,871
North Carolina	6,388	.....	.....	17,000	.....	29,284	.....	52,672
Ohio	1,547,167	603,599	448,516	1,321,921	.....	56,367	298,544	4,405,590
Oklahoma	29,689	205,765	130,732	.....	236	.....	1,046	398,636
Oregon	.....	.....	.....	.....	.....	.....	.....	(a)
Pennsylvania	661,547	172,708	392,267	4,799,546	.....	117,903	164,977	6,367,446
Rhode Island	.....	.....	.....	.....	.....	.....	.....	(a)
South Carolina	.....	.....	.....	.....	.....	.....	.....	(a)
South Dakota	4,000	.....	1,050	.....	3,525	.....	35	17,485
Tennessee	369,296	132,655	86,027	49,545	.....	25,360	2,425	855,245
Texas	151,495	24,100	209,602	25,280	.....	500	1,776	492,255
Utah	3,750	.....	2,810	158,691	28,000	.....	.....	196,271
Vermont	10,465	.....	1,500	254	.....	31,573	3,518	49,405
Virginia	839,858	408,830	71,686	126,623	.....	65,554	13,216	1,534,545
Washington	212	.....	.....	19	752	606	8,964	11,550
West Virginia	114,770	219,839	32,874	518,827	.....	34,112	844	922,766
Wisconsin	426,993	20,537	225,833	33,696	.....	9,075	20,141	894,158
Wyoming	.....	.....	.....	.....	.....	.....	.....	(a)
Undistributed	1,029	11,126	17,337	1,478	80,337	70,719	.....	196,945
	8,164,230	3,604,256	5,334,509	9,672,347	381,038	893,530	1,404,434	35,229,866

a Included in "Undistributed."

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Value of limestone sold in the United States in 1915 and 1916—Continued.

1916.

	Rough building.	Dressed building.	Paving and flagging.	Curbing.	Rubble.	Riprap.
Alabama	(a)	(a)				$17,969
Arizona						(a)
Arkansas					(a)	4,233
California	$325					
Colorado	(a)					
Connecticut						
Florida	(a)	(a)				
Georgia					(a)	
Hawaii						
Idaho	(a)					
Illinois	11,278	(a)	(a)	(a)	$34,603	297,971
Indiana	870,686	$2,532,535	$3,888	$51,400	16,473	23,976
Iowa	9,422	(a)	9,140	(a)	11,104	82,155
Kansas	34,750	25,996	3,580		7,685	44,183
Kentucky	79,818	49,071	(a)	2,993	(a)	36,525
Louisiana						(a)
Maryland	3,569					
Massachusetts						
Michigan	5,633				(a)	(a)
Minnesota	34,064	72,517			12,750	44,710
Missouri	34,891	430,562	1,844	904	139,539	367,484
Montana	3,312		(a)	(a)	(a)	(a)
Nebraska	(a)				8,600	74,027
New Jersey	(a)					(a)
New Mexico						
New York	50,053	9,439	(a)	1,121	1,575	4,989
North Carolina						
Ohio	38,963	(a)		(a)	3,228	63,110
Oklahoma	(a)	(a)	(a)		(a)	14,737
Oregon						
Pennsylvania	44,946	(a)	1,364		(a)	4,824
Rhode Island						
South Dakota						(a)
Tennessee	606	(a)			1,575	59,299
Texas	21,529	8,304		(a)	2,776	33,002
Utah	(a)	(a)				(a)
Vermont	(a)				(a)	
Virginia	1,200	(a)			863	(a)
Washington						
West Virginia	(a)				(a)	
Wisconsin	23,076	2,250	1,127	22,378	52,009	78,202
Wyoming	(a)					
Undistributed	20,139	151,760	3,705	542	4,997	106,181
	1,288,369	3,282,434	24,648	79,338	297,772	1,357,457

a Included in "Undistributed."

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Value of limestone sold in the United States in 1915 and 1916—Continued.

1916—Continued.

	Crushed stone.			Flux.	Sugar factories.	Glass factories.	Agriculture.	Other.	Total.
	Road metal.	Railroad ballast.	Concrete.						
Alabama	$1,198	(a)	$41,321	$807,344	(a)	.....	(a)	$1,977	$917,559
Arizona	.....	.....	(a)	41,426	.....	.....	.....	.....	98,877
Arkansas	(a)	(a)	(a)	(a)	.....	(a)	(a)	608	64,809
California	(a)	(a)	(a)	88,921	$92,380	(a)	$8,188	14,814	277,521
Colorado	.....	.....	.....	332,187	73,922	.....	.....	565	406,974
Connecticut	(a)	.....	.....	(a)	.....	.....	(a)	.....	(a)
Florida	139,474	(a)	153,795	.....	.....	.....	36,836	(a)	479,837
Georgia	(a)	.....	(a)	(a)	.....	.....	(a)	7,500	82,799
Hawaii	.....	.....	.....	.....	.....	.....	(a)	.....	(a)
Idaho	.....	.....	.....	(a)	(a)	.....	.....	(a)	27,721
Illinois	815,779	$390,311	1,228,833	427,058	(a)	$10,861	135,908	6,109	3,362,751
Indiana	810,719	73,078	86,359	132,145	(a)	(a)	32,588	9,527	4,657,813
Iowa	11,374	76,929	342,082	3,407	(a)	.....	9,630	(a)	561,015
Kansas	64,329	143,763	231,744	(a)	.....	.....	1,448	42,106	599,995
Kentucky	639,377	355,564	52,054	31,807	.....	(a)	35,851	4,999	1,288,974
Louisiana	(a)	(a)	(a)	.....	.....	.....	(a)	.....	(a)
Maryland	63,298	22,779	52,799	79,565	.....	.....	(a)	372	223,182
Massachusetts	.....	.....	.....	.....	.....	.....	(a)	.....	(a)
Michigan	420,467	57,950	155,084	1,207,326	41,709	.....	11,068	489,958	2,389,763
Minnesota	8,729	10,799	260,344	.....	1,000	.....	835	22,194	467,942
Missouri	235,625	65,525	582,818	49,227	2,830	38,481	6,063	34,626	1,990,419
Montana	6,151	(a)	9,291	206,153	9,204	.....	.....	.....	237,923
Nebraska	(a)	(a)	290,103	(a)	13,834	.....	.....	(a)	405,867
New Jersey	26,967	.....	7,977	178,266	.....	.....	(a)	(a)	245,019
New Mexico	.....	(a)	.....	.....	.....	.....	.....	.....	(a)
New York	903,350	494,858	687,540	405,774	.....	.....	164,287	312,470	3,035,786
North Carolina	(a)	.....	(a)	(a)	.....	.....	77,101	.....	87,418
Ohio	1,597,284	612,336	817,158	1,636,991	.....	35,643	54,591	467,620	5,337,085
Oklahoma	21,110	336,484	134,827	.....	.....	(a)	(a)	5,381	516,230
Oregon	.....	.....	.....	(a)	(a)	(a)	(a)	.....	(a)
Pennsylvania	450,402	111,202	466,557	6,768,374	.....	74,990	129,574	115,219	8,167,639
Rhode Island	.....	.....	.....	(a)	.....	.....	(a)	(a)	(a)
South Dakota	(a)	.....	(a)	.....	(a)	.....	.....	.....	19,435
Tennessee	311,739	124,514	96,165	65,352	.....	.....	64,910	28,249	752,649
Texas	34,505	26,669	285,440	44,947	.....	(a)	(a)	2,210	459,918
Utah	(a)	.....	(a)	167,888	48,974	.....	.....	(a)	249,998
Vermont	(a)	.....	(a)	(a)	.....	.....	54,535	(a)	68,098
Virginia	230,970	424,957	85,056	189,339	.....	.....	106,166	14,905	1,087,247
Washington	.....	.....	.....	14,813	.....	.....	5,282	(a)	30,338
West Virginia	186,555	177,233	51,530	966,031	.....	.....	74,865	779	1,452,393
Wisconsin	369,725	35,472	389,623	77,968	.....	.....	10,360	26,901	1,089,111
Wyoming	.....	.....	.....	.....	(a)	.....	.....	.....	(a)
Undistributed	74,257	110,224	139,303	16,553	85,841	21,347	126,526	30,550	179,766
	7,417,384	3,650,647	6,647,803	13,936,882	369,694	181,322	1,146,582	1,639,639	41,319,871

a Included in "Undistributed."

As appears in the tables on pages 1046 to 1049, showing the value of limestone by States and uses, the increase in value in 1916 was mainly due to stone used for flux, whose increase ($4,264,535) far exceeded the sum of all decreases. This remarkable increase followed an increase in 1915 of $1,781,978. Other products showing considerable increase were crushed stone for concrete ($1,313,294) and "other" ($235,205). Dressed building, agricultural, and "other" stone, together with riprap, increased in 1915 as well. The principal decrease in 1916 was in crushed stone for road metal ($746,846) and in stone for rough building ($200,676). Crushed stone, as usual, was the most important product, its total value in 1916 being $17,715,834, a net increase of $612,839 following a decrease in 1915 of $958,886.

The figures in the foregoing tables represent only the value of limestone sold or used as such by the producers. In addition large quantities of limestone are used in the manufacture of Portland cement

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and lime. A relatively small quantity is used in the manufacture of natural cement. As these products are manufactured by the companies quarrying the stone and as the values of the manufactured products are given in other chapters of Mineral Resources, the value of the raw material is excluded from the tables of this chapter to avoid duplication.

Limestone used in certain industries, 1915–1916, in short tons.

	1915	1916
Portland cement (including limestone and some "cement rock")	24,095,355	33,651,283
Natural cement (cement rock)	153,060	158,054
Lime	7,179,358	7,685,728
	31,427,773	41,495,065

If the average cost per ton of limestone is assumed to have been 35 cents in 1916 as in 1915, the total values represented by these quantities were $10,999,721 in 1915 and $14,523,273 in 1916. Owing to the general increase in cost of quarrying in 1916, the estimated value for that year is undoubtedly low.

Closely associated with limestone in commercial usage as well as in chemical consumption and mode of occurrence is calcareous marl. A rough estimate of the quantity of marl used in manufacturing Portland cement in 1916 is 1,060,000 short tons. No data for estimating the cost of production are available. Besides this quantity there were produced for agricultural use 35,588 short tons of marl, valued at $107,768. If these values of limestone and marl were added to the total value in the table on page 1049, the grand total value of limestone produced in 1916 would be, in round numbers, about $57,000,000.

BUILDING STONE.

Building stone in 1916, as in the two preceding years, represented 11 per cent of the total value of limestone. The combined value of rough and dressed stone in 1916 increased $514,502, or 11 per cent, following an increase of 4 per cent in 1915 and slightly exceeded the value for 1913 but was less than that for any of the four years from 1909 to 1912, inclusive. The increase in both 1915 and 1916 was due to dressed building stone, which passed well beyond its previous record value of 1910. The value of rough building stone, on the other hand, had decreased steadily since 1912, and with only two exceptions since 1905. Indiana and Missouri, the two leading States, showed increase in total value in both 1915 and 1916,; Kentucky, which ranked third, showed increase in 1916; and Minnesota, the fourth State, showed decrease in each year. These four States represented 90 per cent of the total value of limestone sold for building in 1916 compared with 88 per cent in 1915.

INDIANA.

The total value of Indiana oolitic limestone quarried and sold at Bedford and Bloomington in 1916 was $3,480,525, a gain of $462,354, or more than 15 per cent, over the value for 1915. This sum exceeds

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by even greater amounts the values for 1914 and 1913, but was $65,240, or nearly 2 per cent, less than the record value of 1912, as is shown in the following table:

Bedford oolitic limestone quarried and sold in Lawrence and Monroe counties, Ind., 1901–1916.

Year.	Lawrence County.		Monroe County.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1901	.....	$1,365,875	.....	$421,599	.....	$1,787,474
1902	.....	1,207,497	.....	439,902	.....	1,637,399
1903	.....	1,088,477	.....	487,662	.....	1,576,139
1904	.....	1,054,302	.....	589,672	.....	1,643,974
1905	.....	1,550,076	.....	843,399	.....	2,393,475
1906	[a] 4,715,858	1,460,743	[a] 4,566,146	1,162,062	[a] 9,282,004	2,622,805
1907	[a] 4,497,968	1,413,280	[a] 3,351,059	908,612	[a] 7,849,027	2,321,892
	[b] 167,714	101,100	[b] 89,246	9,525	[b] 256,960	110,625
1908	[a] 5,199,996	1,498,822	[a] 3,147,097	880,218	[a] 8,347,093	2,379,040
	[b] 93,085	42,150	[b] 8,260	1,719	[b] 101,705	43,869
1909	[a] 6,441,483	1,678,195	[a] 2,970,388	801,436	[a] 9,411,871	2,479,631
	[b] 145,672	71,637	[b] 106,600	56,925	[b] 252,272	128,562
1910	[a] 5,778,660	1,841,233	[a] 3,960,148	1,265,287	[a] 9,738,808	3,106,520
	[b] 131,590	75,906	[b] 70,655	44,224	[b] 202,245	120,130
1911	[a] 6,612,988	2,171,148	[a] 2,915,444	859,580	[a] 9,528,442	3,030,728
	[b] 53,242	27,842	[b] 50,914	45,112	[b] 104,156	72,954
1912	[a] 7,066,496	2,622,648	[a] 3,375,808	824,594	[a] 10,442,304	3,447,242
	[b] 71,124	37,894	[b] 76,532	60,629	[b] 147,656	98,523
1913	[a] 5,737,303	2,095,461	[a] 3,273,369	992,286	[a] 9,010,672	3,087,747
	[b] 91,034	50,092	[b] 67,035	41,508	[b] 158,069	91,600
1914	[a] 5,249,651	1,920,904	[a] 2,679,355	750,311	[a] 7,929,006	2,671,215
	[b] 83,590	30,384	[b] 21,860	17,010	[b] 105,450	47,394
1915	[a] 6,143,282	2,102,814	[a] 2,541,931	830,613	[a] 8,685,213	2,933,427
	[b] 114,547	64,491	[b] 34,032	20,253	[b] 148,579	84,744
1916	[a] 5,940,055	2,519,690	[a] 2,605,479	873,886	[a] 8,545,534	3,393,576
	[b] 187,270	69,546	[b] 24,966	17,403	[b] 212,236	86,949

[a] Cubic feet. [b] Short tons.

Nearly 98 per cent of the total value of Indiana limestone in 1916 was represented by building stone, valued at $3,393,576, an increase of $460,149, or nearly 16 per cent, over 1915. This value represented 74 per cent of the total value of limestone sold for building in 1916, compared with 72 per cent in 1915 and 69 per cent in each of the two preceding years; it also represented 28 per cent of the total value of all kinds of building stone in 1916, compared with 19 per cent in 1915 and 15 per cent in 1914. The average price per cubic foot in 1916 increased from 34 to 40 cents, but the total quantity of building stone sold, 8,545,534 cubic feet, was less by 139,679 cubic feet, or 1.6 per cent, than the quantity sold in 1915.

The gain in the value of building stone, as well as of all stone, was principally in sawed or cut stone, the quantity sold in 1916 amounting to 4,313,098 cubic feet, valued at $2,523,540. The output of such stone exceeded that of 1915 by 813,783 cubic feet, or more than 23 per cent, in quantity and by $596,984, or 31 per cent, in value. On the other hand, the output of rough building stone decreased both in quantity and value. The quantity sold in 1916 was 4,232,436 cubic feet, a decrease of 953,462 cubic feet, or more than 18 per cent, and the value was $870,036, a decrease of $136,835, or nearly 14 per cent.

The average price per cubic foot, however, of both rough and sawed or cut stone increased in 1916, that of rough stone from 19 to 21 cents and that of sawed or cut stone from 55 to 59 cents. This

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increase in price may be attributed in part to increased cost of production and in part to cessation of the ruinous practice of price cutting that prevailed in previous years.

The slight decrease in the total quantity of building stone sold in 1916 may be surprising in view of the great increase in building activity during that year. A great part of this increase, however, is said to be represented by factories and other industrial plants, in which little or no building stone is used. Many dwelling and apartment houses, in which the greater part of Indiana oolitic limestone is used for window sills, steps, balustrades, and other trimmings, were also erected, but few stone-faced buildings that required large quantities of stone were built in 1916.

The stone sold in 1916 for other uses than building amounted to 212,236 short tons, valued at $86,949, a gain of 63,657 tons, or nearly 43 per cent in quantity, but of only $2,203, or less than 3 per cent, in value. The price per ton dropped from 77 to 41 cents. Stone of this class was used principally for breakwater work around Indiana Harbor, on Lake Michigan, and as furnace flux, the demand for which was very great. The decrease in price during a year of prevailing high prices is striking, but the increase in quantity is a gratifying indication that progress is being made in utilizing stone that would otherwise be discarded as waste.

The following table shows the quantity and value of oolitic limestone produced in 1915 and 1916 in the Bedford-Bloomington district:

Bedford oolitic limestone sold in Lawrence and Monroe counties, Ind., in 1915 and 1916.

County.	Building stone.						Other stone.[a]		Total value.
	Rough.		Sawed or cut.		Total.		Quantity (short tons).	Value.	
	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.			
1915.									
Lawrence	3,955,350	$804,312	2,187,932	1,298,502	6,143,282	$2,102,814	114,547	$64,491	$2,167,305
Monroe	1,230,548	202,559	1,311,383	628,054	2,541,931	830,613	34,032	20,253	850,866
	5,185,898	1,006,871	3,499,315	1,926,556	8,685,213	2,933,427	148,579	84,744	3,018,171
Average price.		0.19		0.55		0.34		0.77	
1916.									
Lawrence	3,197,345	696,968	2,742,710	1,822,722	5,940,055	2,519,690	187,270	69,546	2,589,236
Monroe	1,035,091	173,068	1,570,398	700,518	2,605,479	873,898	24,966	17,403	891,299
	4,232,436	870,036	4,313,098	2,523,240	8,545,534	3,393,576	212,236	86,949	3,480,525
Average price.		0.21		0.59		0.40		0.41	
Percentage of increase or decrease in 1916.	−18.4	−13.6	+23.3	+31.0	−1.6	+15.7	+42.8	+2.6	+15.3

[a] Includes stone used for rubble, riprap, curbstone, flagstone, glass making, sugar factories, ground limestone, etc.

MISSOURI.

Missouri showed a gain in total value of $62,885, or 3 per cent, following an increase of 25 per cent in 1915. This gain was due to dressed stone, which more than offset the continued decrease in value of rough stone. About 92 per cent of the limestone sold for building

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stone in 1916 was quarried in the Carthage district, compared with 70 per cent in 1915 and 66 per cent in 1914. The gain in building stone, including marble, in the Carthage district in 1916 was nearly 16 per cent in quantity and more than 29 per cent in value, following gains of 31 per cent and 86 per cent, respectively, in 1915. The average price of building stone, rough and dressed, was $1.17 a cubic foot in 1916.

Total sales of limestone and marble in the Carthage district, as shown in the table below, increased 31 per cent in value. In this table the quantity and value of monumental stone are shown for the first time in the figures for 1916. The values for curbing, flagging, and rubble are too small for annual increase or decrease to be of much significance. "Other" stone includes mainly crushed stone and stone for glass factories, blast furnaces, and sugar factories.

Limestone and marble sold at Carthage, Jasper County, Mo., in 1908–1916.

Year.	Number of producers.	Monumental stone, rough.[a]		Building stone (rough and dressed).		Curbing.	Flagging.	Rubble.	Other.[b]	Total value.
		Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.					
1908	8	.....	.....	431,576	$280,249	$5,238	$3,602	$2,682	$17,826	$309,597
1909	8	.....	.....	481,274	334,715	1,263	6,232	3,791	24,001	370,002
1910	10	.....	.....	502,161	347,244	1,767	7,229	2,945	23,571	382,756
1911	9	.....	.....	427,974	293,470	2,427	2,431	2,596	23,865	324,789
1912	8	.....	.....	404,685	268,930	670	2,878	4,885	28,087	305,450
1913	7	.....	.....	346,421	236,524	.....	2,367	1,500	18,564	258,955
1914	7	.....	.....	280,046	206,554	.....	2,883	1,951	21,426	232,814
1915	7	.....	.....	367,950	384,959	(c)	2,614	[c] 1,220	25,471	414,264
1916	7	25,232	$22,054	426,408	497,357	(c)	1,684	2,675	20,029	543,799
Average price 1916	.....	.....	0.87	.....	1.17	.....	.....	.....	.....	.....
Percentage of increase or decrease	.....	.....	.....	+15.9	+29.2	.....	−35.6	+119.2	−21.3	+31.3

[a] Prior to 1916 included under "Other."
[b] Includes stone use used for monumental work (prior to 1916), crushed stone, stone sold to glass factories, blast furnaces, sugar factories, etc.
[c] Curbing included in flagging; rubble includes riprap.

KENTUCKY.

Kentucky, with a gain of $15,382, or more than 13 per cent, in 1916 passed Minnesota and attained third place among States producing limestone for building. The greater part of Kentucky's production of limestone for building continues to come from the Bowling Green district, whose sales in 1916 represented 79 per cent of the State's total, compared with 78 per cent in 1915. The total value of limestone quarried in this district in 1916, as shown in the table below, increased $12,709, or 13 per cent, compared with 1915. Rough building stone, the main product, increased 14 per cent in quantity and 29 per cent in value, its average price increasing 5 cents a cubic foot. Dressed building stone showed increase of about 4 per cent in both quantity and value, its average price remaining the same as in 1915. The quantity of crushed stone sold in 1916 was less than one-third of that sold in 1915, but its average price more than doubled.

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Limestone sold in Warren County, Ky., 1909–1916.

Year.	Rough building.		Dressed building.		Crushed stone.		Other.a	Total value.
	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (short tons).	Value.		
1909	203,120	$60,936	74,482	$62,960	46,725	$22,013	$33,704	$179,642
1910	204,602	56,141	90,100	57,350	108,183	47,532	5,584	166,607
1911	134,291	45,792	103,220	76,589	57,720	25,921	250	148,552
1912	148,711	51,638	114,308	100,774	38,495	17,563	1,890	171,965
1913	110,576	36,388	95,915	74,250	37,972	20,476	2,045	133,159
1914	104,895	36,043	80,427	60,292	39,906	22,344	.....	118,679
1915	125,112	41,693	60,641	46,424	17,859	8,339	300	96,756
1916	142,690	53,695	62,865	48,503	5,608	5,326	300	109,465
Average price	.....	0.38	.....	0.77	.....	0.95	.....	.....

a Curbing, flagging, fluxing, and monumental stone.

MINNESOTA.

The value of limestone for building in Minnesota in 1916 decreased $9,094, or 8 per cent, following a decrease of 28 per cent in 1915. Kasota and Mankato are the principal districts, but details of their production can not be given without disclosing individual figures for certain kinds of stone. One company reported increased sales of stone for interior work.

OTHER STATES.

Of the other States furnishing considerable quantities of limestone for building, Kansas and Florida were the only ones to show increase in value in 1916. New York's decrease was in the value of dressed stone, and that of Ohio, Pennsylvania, and Wisconsin was in the value of rough stone.

LIMESTONE FOR OTHER USES.

Of the limestone sold for other uses than building, that for paving decreased and that for flagging increased in 1916, their combined values showing decrease of $2,506. Stone for curbing decreased $1,077. These small decreases would indicate that both demand and competition with concrete remained about the same as in 1915. As the outputs of single quarries are prevailingly small and correspondingly more seriously affected by shortage of labor and high costs of production, these factors may have sufficed to offset an increase in demand that would have been expected in 1916.

Rubble.—The value of rubble decreased in 1916, as in each of the seven preceding years—the decrease amounting to $8,344, or nearly 3 per cent. Five of the 13 States whose value is separately shown, however, showed increase. These were Wisconsin, Nebraska, Missouri, Ohio, and Texas. Missouri, the leading State, showed a small increase in 1915 also. Illinois, Kansas, and Minnesota showed the largest decrease. Owing to the variable demand for rubble, marked fluctuations in its marketed production in individual States are to be expected. The general decline in its use in the country as a whole during the last eight years is probably more than balanced by increased use of concrete for the same class of work, and the grad-

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ually lessened degree of decline suggests that an approximate balance has been reached where the amount of work for which rubble is the most available material is practically constant.

Riprap.—The value of limestone for riprap increased $51,821, or nearly 4 per cent, in 1916, following an increase of $182,513 in 1915. The principal gains were made by Missouri and Illinois, the two leading States, and by Nebraska, and by far the largest loss was suffered by Tennessee. Illinois showed a gain in 1915 also. Completion of harbor improvement work in Texas was followed by other work, which maintained the State's output of riprap. Total sales of riprap in the United States increased steadily from 1906 to 1911, when they attained their maximum value. Since that year they have fluctuated, with a small net decline, indicating that the amount of construction work calling for this kind of stone has on the whole remained constant.

Crushed stone.—The total value of crushed stone increased $612,839, or nearly 4 per cent, in 1916, following a decrease of $958,886 in 1915. The gain in 1916 was made almost entirely by stone for concrete, which increased $1,313,294, or nearly 25 per cent. Stone for railroad ballast showed a relatively small gain, $46,391, and stone for road metal decreased $746,846 in value. As some producers can subdivide their product only approximately, and as some of the stone reported for concrete may have gone into concrete roads, the reported decrease in value of stone for road metal should be regarded not as indicating a decline in road building activity but as showing a general decrease in the use of crushed limestone for asphalt and water-bound macadam. Decreased activity in road building was reported from a few places, partly owing to shortage of labor, which also affected the quarries. Some reduced outputs were attributed to keen competition with gravel and, in the Missouri-Kansas region, with "chats" or tailings from the zinc-lead mines.

Furnace flux.—The greatly increased activity in the iron and steel industries in 1916 caused an enormous increase in the quantity of limestone marketed for furnace flux, which amounted to 23,603,508 long tons, valued at $13,936,882, an increase in quantity of 4,604,785 tons, or 24 per cent, and in value of $4,264,535, or 44 per cent, compared with 1915. The average price per ton increased from 51 to 59 cents. This increase followed an increase of 3,699,967 tons, valued at $1,781,978 in 1915, and far surpassed the record value of 1913. All the important States except New York, according to the accompanying table, showed marked increase, and Maryland joined the States with an output of more than 100,000 long tons. Pennsylvania, the leading State, exceeded 10,000,000 long tons for the first time, and its quantity continued to be more than three times the quantity of the second State, Ohio. Five States exceeded 1,000,000 long tons in quantity in 1916, compared with three in the two preceding years. The marketed production of furnace flux, although increasing as a whole since 1900, has fluctuated, a marked decrease coming on the average every third year. The condition of the iron industry during the first six months of 1917 indicates that a comparatively small decrease may be recorded for that year.

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Furnace flux sold in the United States in 1915 and 1916.

State.	1915		1916	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.
Alabama	523,096	$289,167	857,785	$607,344
Arizona	1,400	1,330	68,059	41,426
Arkansas	22	33	(a)	(a)
California	57,991	70,087	79,607	86,921
Colorado	453,365	272,093	554,147	332,127
Connecticut	2,675	1,675	(a)	(a)
Georgia	3,741	3,453	(a)	(a)
Idaho			(a)	(a)
Illinois	873,095	348,547	1,120,175	427,068
Indiana	139,473	69,834	282,748	132,145
Iowa	3,704	2,905	4,398	3,407
Kansas	697	533	(a)	(a)
Kentucky	20,969	19,259	49,447	31,807
Maryland	4,332	2,059	146,276	79,585
Michigan	2,254,984	763,029	3,033,155	1,207,228
Minnesota	564	664		
Missouri	28,906	26,591	61,500	49,227
Montana	632,216	189,576	633,729	206,153
Nebraska			(a)	(a)
New Jersey	298,308	141,915	289,043	178,286
New York	732,181	416,712	657,788	405,774
North Carolina	24,000	17,000	(a)	(a)
Ohio	2,696,321	1,321,921	3,281,324	1,636,991
Oregon			(a)	(a)
Pennsylvania	8,625,696	4,799,546	10,019,046	6,798,374
Rhode Island	(a)	(a)	(a)	(a)
Tennessee	88,823	49,545	113,149	65,352
Texas	37,499	25,280	60,424	44,947
Utah	248,181	158,691	292,681	167,888
Vermont	253	254	(a)	(a)
Virginia	200,465	126,623	361,508	189,339
Washington	25	19	17,582	14,813
West Virginia	976,044	518,827	1,451,700	986,031
Wisconsin	66,352	33,696	131,566	77,968
Undistributed	868	1,478	16,571	16,553
	18,998,723	9,672,347	28,608,506	13,986,852
Average price per ton		$0.51		$0.59
Per cent of increase			34.2	44.1

a Included in "Undistributed."

Sugar factories.—Limestone sold to sugar factories in 1916 showed a decreased value of $11,344, compared with 1915, though it exceeded the value for 1914. Sales of raw limestone to sugar factories since 1905 have shown some fluctuation in value from year to year, but have made a small net increase. This value, however, represents only a part of the total quantity of limestone quarried for sugar factories, as a number of the manufacturing companies quarry and burn their own stone and report their output as lime, which is included in the chapter on lime. The total value of lime and limestone for sugar factories in 1916 was $488,266, a decrease of $123,140, compared with 1915, and the lowest value recorded since 19—. This reduced value, however, may be the direct result of the large sales in 1915, as the sugar manufacturing industry showed no decline in 1916.

Agricultural use.—Pulverized limestone continued to increase in favor as a soil sweetener. Since the figures of production were first compiled, in 1911, this industry has steadily increased, as is shown in the accompanying table, and the output for 1916—1,066,376 short tons, valued at $1,146,582—represents a gain of 512 per cent in quantity and 460 per cent in value for the six years. The increase for 1916 compared with 1915 was about 32 per cent in quantity and 28 per cent in value, the average price per ton decreasing 2 cents.

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In some localities pulverized limestone was a by-product of crushed stone or the waste from quarries of building stone; in others it was the only product of the quarry.

Lime and pulverized limestone produced for use in agriculture, 1911–1916.

Year.	Lime.		Limestone.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1911	506,664	$1,714,386	174,290	$205,006
1912	604,607	1,852,530	200,000	311,702
1913	590,229	1,798,566	406,627	493,718
1914	684,348	2,139,444	615,197	668,961
1915	673,260	2,163,874	810,399	893,530
1916	613,564	2,224,058	1,066,376	1,146,582
Average price per ton				1.08
Increase or decrease (per cent)	−8.9	+2.8	+31.6	+28.3

Burned lime for agriculture, according to the table, decreased in quantity in 1915 and 1916, although its value increased both years. As this lime in 1916 was equivalent to about 1,158,000 short tons of limestone, the total quantity of limestone used by farmers in 1916 was about 2,224,000 short tons.

The following table shows for the first time the quantity and value of pulverized limestone produced in different States:

Ground limestone sold for agricultural purposes in 1916.

State.	Quantity (short tons).	Value.	State.	Quantity (short tons).	Value.
Alabama	(a)	(a)	New York	102,606	$164,237
Arkansas	(a)	(a)	North Carolina	53,532	77,101
California	5,602	$8,188	Ohio	55,236	54,591
Connecticut	(a)	(a)	Oklahoma	(a)	(a)
Georgia	(a)	(a)	Oregon	(a)	(a)
Hawaii	(a)	(a)	Pennsylvania	73,301	129,574
Illinois	203,829	135,908	Rhode Island	(a)	(a)
Indiana	39,596	32,588	Tennessee	66,854	64,910
Iowa	17,526	9,630	Texas	(a)	(a)
Kansas	1,870	1,448	Vermont	27,489	54,535
Kentucky	34,645	35,851	Virginia	146,703	106,166
Louisiana	(a)	(a)	Washington	1,881	5,262
Maryland	(a)	(a)	West Virginia	47,709	74,865
Massachusetts	(a)	(a)	Wisconsin	11,920	10,360
Michigan	30,543	11,088	Undistributed	108,724	126,526
Minnesota	1,412	835			
Missouri	5,946	6,063		1,066,376	1,146,582
New Jersey	(a)	(a)			

a Included in "Undistributed."

In addition to pulverized limestone calcareous marl used for soil sweetening was reported to the United States Geological Survey in 1916 from Arkansas, California, New York, Pennsylvania, South Carolina, and Virginia. The output was 35,588 short tons, valued at $107,768, or $3.03 a ton. Individual reports gave prices ranging from $1 to $3 a ton in the Southern States and from $4 to $6 a ton in the Northern States and California. Sales of this material in former years have been included in those of limestone.

"Other" uses.—The column headed "Other" in the table on page 1049 is in part itemized as follows:

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Limestone used for special purposes in 1915 and 1916.

Use.	1915		1916	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alkali works	1,621,682	$765,828	2,835,557	3966,262
Glass factories	148,638	129,920	193,028	181,322
Paper mills	52,262	40,588	80,338	58,785
Carbonic-acid plants	206,552	61,028	(a)	(a)
Lime burners	115,068	75,656	130,729	81,473
Miscellaneous [b]	.....	331,414	.....	351,797
	.....	1,404,434	.....	1,639,639

[a] Included in "Miscellaneous."
[b] Includes limestone sold for crushing; for putty, paint, and asphalt filler; for mineral wool, whiting, ammonia, basic magnesium carbonate, and other chemical uses.

Limestone for alkali works, the principal item, showed marked increase in quantity and value, owing to the increased demand for certain alkali salts caused by the war. Further increase will doubtless appear in the figures for 1917.

Stone sold to glass factories also showed a large percentage of increase. The value of this product by States in 1916 is shown in the table on page 1049.

Limestone for paper mills showed increase in quantity and value. Burned lime for the same use, 353,187 short tons, valued at $1,461,412, also showed increase in 1916, as shown in the chapter on lime.

Limestone sold to lime burners, which also increased in both quantity and value, was produced mainly in Ohio, Pennsylvania, and Virginia.

The most important of the unitemized uses in 1916 were asphalt filler (about 33,000 tons, valued at $82,000), magnesia and basic magnesium carbonate (80,867 tons, valued at $80,595), and chicken grit (about 10,850 tons, valued at $33,300).

A relatively small quantity of limestone was used for the manufacture of whiting. The greater part of this material has been manufactured from English chalk, whose imports are included in the following table:

Chalk, etc., imported for consumption, 1915–16.

	1915		1916	
	Quantity.	Value.	Quantity.	Value.
Chalk, crude, not precipitated, or otherwise manufactured (duty free).....tons..	111,501	$79,950	133,188	$112,671
Ground or bolted (duty 0.1 cent a pound).....pounds..	75,018	486	.....	.....
Precipitated, for medicinal purposes (duty 25 per cent).....	.....	42,420	.....	27,713
Forms of cubes, blocks, sticks, dishes, or otherwise, including tailor's, billiards, etc. (duty 25 per cent).....	.....	4,592	.....	4,096
French, cut, powdered, washed, or pulverized (duty 15 per cent).....	.....	129	.....	626
Manufactured, not elsewhere specified (duty 25 per cent)...	.....	160	.....	249
Whiting and Paris white, dry (duty 0.1 cent a pound), pounds..	3,493,308	12,774	2,308,726	9,952
Whiting and Paris white, ground in oil or putty (duty 15 per cent).....pounds..	16,402	395	28,334	972

Domestic chalk deposits, so far as they have been prospected, have proved to be too impure for use in the manufacture of whiting.

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LITHOGRAPHIC STONE.

In 1916 for the first time there was a considerable production of lithographic stone in this country. This production was made by the Kentucky Lithograph Stone Co., which has quarries at Brandenburg, Ky., and an office in Louisville. In 1916 the company sold 40,000 pounds of finished stone at prices ranging from 2½ to 27 cents a pound. For some years previously small quantities had been sold occasionally in Louisville, but in 1916 the stone was shipped to buyers as far away as Cleveland, Washington, New York, and Boston.

The quarry at Brandenburg contains three distinct beds from which lithographic stone may be obtained. Two of these beds are about 3 feet thick and one is 9 to 10 feet thick. They are separated by beds of limestone of other varieties and make up only about 20 per cent of the stone that must be removed. The remaining 80 per cent, however, is available for crushed and pulverized limestone, chicken grit, and other uses, and considerable quantities were marketed for these purposes in 1916.

The greatest difficulty in the development of lithographic-stone quarries in the United States has been the high cost of quarrying and preparing the stone in competition with the well-known Bavarian stone. Much of this stone is reported to occur in thin layers that require only planing and polishing before use, whereas known deposits in the United States that are at all suitable for lithographic work occur in more massive beds that must first be sawed into slabs of proper thickness. High cost of labor in the United States and of railroad as compared with ocean transportation have also stood in the way of the domestic industry.

Quarrying of the Bavarian stone, however, involves the handling of large quantities of waste, and the waste piles around the quarries to-day form hills of considerable size. The marketing of crushed stone and similar products from the Brandenburg quarry should go far toward eliminating the cost of quarrying from the expense of preparing lithographic stone. With this advantage it may be possible, even after the European war is over, to market the Kentucky stone in competition with the Bavarian stone, the better grades of which under normal conditions bring 5 to 6 cents a pound for 10 by 12 inch slabs, and the poorer grades 1½ cents a pound for slabs of the same size.

The value of imports of lithographic stone at the customs district of New York for the calendar year 1916 was reported as follows by the collector of the port to the Bureau of Foreign and Domestic Commerce, Department of Commerce: Italy, $434; England, $191; Canada, $124; total, $749.

SANDSTONE.

The value of marketed sandstone continued to decrease in 1916, dropping to $5,603,778, 8 per cent less than in 1915 and the lowest value for sandstone since 1897.

The decline in value of sandstone sold since 1903, as shown in Plate I, has been interrupted in only three years, 1909, 1913, and 1914. In 1916 the value of sandstone sold represented 7 per cent of the total value of stone. The three leading States, which contributed 59 per cent of the total value of sandstone were Pennsylvania ($1.318.239),

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Ohio ($1,274,181), and New York ($714,558). In 1915 Ohio was the leading State.

Pennsylvania was the only one of these States having increased sales (5 per cent) in 1916, and this increase was in the value of ganister, which, together with a small increase in crushed sandstone, more than offset declines in all other kinds. Ohio's principal products, as in former years, were building stone, curbing, and flagging, the output of each of which decreased in 1916. Ohio's output of sandstone also included a considerable production of grindstones, whose value is recorded in the chapter on abrasives. New York's principal sandstone products—building stone, paving, curbing, flagging, and crushed stone—also showed marked decrease in 1916, and the State's total value fell below $1,000,000 for the first time since complete statistics of sandstone have been collected by the Survey.

Other States, the value of whose production in 1916 exceeded $100,000, according to the accompanying tables, were California, Massachusetts, Wisconsin, Minnesota, South Dakota, and Kentucky. Crushed stone was the principal product in all of these except Wisconsin, where ganister was the leading product, and Kentucky, where building stone and riprap constituted nearly the whole output. Massachusetts was the only one of these States whose value decreased in 1916. New Mexico's large decrease was due to completion of the Elephant Butte dam, which had caused an unusually large production in 1914 and 1915.

Value of sandstone (including quartzite and bluestone) produced and sold in the United States, 1912–1916.

State.	1912	1913	1914	1915	1916
Alabama	$27,596	$151,111	$161,773	$30,432	$20,995
Arizona	21,524	88,391	23,760	9,625	(a)
Arkansas	80,538	89,395	79,358	54,747	95,398
California	70,724	139,486	277,657	336,629	422,226
Colorado	108,169	96,964	97,029	52,457	53,902
Connecticut	(a)	(a)	(a)	(a)	(a)
Florida	(a)	(a)			
Georgia	(a)	(a)			
Idaho	13,883	20,111	22,537	10,302	47,061
Illinois	32,720	28,781	72,738	43,307	40,343
Indiana	(a)	(a)	(a)	(a)	
Iowa	1,551	1,612	1,319	(a)	(a)
Kansas	6,031	1,602	2,274	(a)	3,495
Kentucky	114,650	81,171	60,926	70,164	114,126
Maryland	15,950	16,435	8,126	11,033	6,003
Massachusetts	307,838	404,817	428,926	353,062	318,962
Michigan	16,438	19,224	(a)	(a)	21,449
Minnesota	349,063	315,149	210,099	173,995	186,179
Missouri	15,004	10,195	3,588	10,104	14,981
Montana	33,280	51,081	(a)	6,346	(a)
Nebraska	(a)	(a)	(a)	(a)	(a)
New Jersey	106,583	69,584	53,394	63,964	46,085
New Mexico	(a)	66,700	412,845	206,809	18,330
New York	b 1,651,317	b 1,568,952	b 1,475,231	b 1,000,523	b 714,558
North Carolina	(a)	(a)	(a)	27,544	(a)
Ohio	1,312,300	1,316,028	1,523,796	1,411,333	1,274,181
Oklahoma	5,334	1,010	1,934	2,525	24,229
Oregon		(a)	(a)	(a)	(a)
Pennsylvania	b 1,367,601	b 1,359,533	b 1,140,182	1,253,994	b 1,318,239
South Dakota	139,167	163,165	126,413	119,225	163,735
Tennessee	(a)	(a)	(a)	(a)	(a)
Texas	82,501	58,750	197,800	73,128	85,940
Utah	32,562	23,965	67,578	27,267	27,207
Virginia	4,020	(a)	150,469	178,775	66,217
Washington	344,476	560,468	450,436	(a)	(a)
West Virginia	183,410	146,698	142,459	124,929	48,416
Wisconsin	179,352	213,229	167,595	180,198	188,791
Wyoming	3,730	(a)	11,831	10,840	(a)
Undistributed	206,299	185,358	129,433	141,908	282,741
	6,893,611	7,248,965	7,501,808	6,095,800	5,603,778

a Included in "Undistributed." b Includes bluestone.

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Value of sandstone (including quartzite and bluestone) produ States in 1915 and 1916—Continue

1915.

State.	Rough building.	Dressed building.	Ganister.	Paving.
Alabama	$150	.....	$4,500	.....
Arizona	125	.....	.....	.....
Arkansas	333	.....	.....	$8,505
California	2,800	.....	.....	.....
Colorado	3,280	$1,277	7,827	12,060
Connecticut	(a)	(a)	.....	.....
Idaho	4,959	4,931	.....	.....
Illinois	306	.....	1,500	.....
Indiana	(a)	.....	.....	.....
Iowa	(a)	.....	.....	.....
Kansas	(a)	.....	.....	.....
Kentucky	2,205	57,779	.....	.....
Maryland	2,175	.....	3,208	.....
Massachusetts	35,290	5,030	.....	.....
Michigan	(a)	(a)	.....	.....
Minnesota	430	40,654	.....	38,771
Missouri	1,124	5,944	.....	.....
Montana	40	4,125	.....	.....
Nebraska	(a)	.....	.....	.....
New Jersey	33,255	13,726	.....	325
New Mexico	900	60	.....	.....
New York	35,790	170,985	.....	259,923
North Carolina	.....	1,100	.....	.....
Ohio	66,759	401,980	1,600	.....
Oklahoma	3	.....	.....	.....
Oregon	(a)	.....	.....	.....
Pennsylvania	139,991	182,674	276,505	113,133
South Dakota	2,948	15,963	545	3,780
Tennessee	.....	.....	(a)	.....
Texas a	.....	.....	.....	.....
Utah	272	.....	.....	26,987
Virginia	.....	.....	.....	.....
Washington	.....	(a)	(a)	(a)
West Virginia	3,588	30,898	.....	100
Wisconsin	9,340	22,498	40,062	55,492
Wyoming	2,380	.....	.....	.....
Undistributed	83,744	24,006	500	13,704
	432,192	984,650	336,267	532,780

a Included in "Undistributed."

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Value of sandstone (including quartzite and bluestone) produced and sold in the United States, 1915–1916—Continued.

1915—Continued.

State.	Riprap.	Crushed stone.			Other.	Total value.
		Road metal.	Railroad ballast.	Concrete.		
Alabama	$12,455					$30,432
Arizona				$2,000	$7,500	9,625
Arkansas	11,003	$15,000	$17,400	2,451		54,747
California	74,742	109,632	26,924	107,368	5,206	336,629
Colorado	4,914	3,100	2,200	10,000	1,730	52,487
Connecticut	(a)				(a)	(a)
Idaho	124					10,302
Illinois		41,313		88		43,307
Indiana	(a)					(a)
Iowa		(a)		(a)		(a)
Kansas						(a)
Kentucky	8,880			300	400	70,164
Maryland	323	2,700				11,038
Massachusetts		72,975		222,997		353,662
Michigan	(a)					(a)
Minnesota	1,990	26,223		29,840	5,555	173,995
Missouri	2,342					10,104
Montana	450					6,346
Nebraska						(a)
New Jersey	1,200	9,000		4,933	950	68,963
New Mexico	34,287	407		222,950		296,804
New York	4,831	65,866	14,735	84,519	23,794	1,000,529
North Carolina		5,220	13,261	5,963	2,000	27,543
Ohio	58,358	20,509		15,752	6,385	1,411,334
Oklahoma				2,500	22	2,525
Oregon						(a)
Pennsylvania	35,942	115,309	84,781	113,608	27,673	1,273,994
South Dakota	9,059	1,952		82,471		119,225
Tennessee						(a)
Texas	60,128	10,000	3,000			73,128
Utah						27,267
Virginia		160,600	10,604	7,271		178,775
Washington	(a)					(a)
West Virginia	17,538	14,336	31,664	17,538	4	134,929
Wisconsin	13,352	16,767	1,200	11,351		180,198
Wyoming				8,160		10,840
Undistributed	10,232	82		258	135	141,908
	362,150	690,991	205,769	952,318	81,354	6,095,800

a Included in "Undistributed."

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Value of sandstone (including quartzite and bluestone) produced and sold in the United States, 1915–1916—Continued.

1916.

State.	Rough building.	Dressed building.	Ganister.	Paving.	Curbing.	Flagging.	Rubble.
Alabama	(a)	.....	(a)	.....	.....	.....	(a)
Arizona	.....	.....	.....	.....	.....	.....	.....
Arkansas	(a)	(a)	.....	(a)	.....	(a)	.....
California	$7,079	.....	.....	.....	.....	.....	.....
Colorado	3,790	$2,842	(a)	$10,678	$1,003	$986	$5,323
Connecticut	(a)	(a)	.....	.....	.....	.....	(a)
Idaho	(a)	(a)	.....	.....	.....	.....	(a)
Illinois	(a)	.....	(a)	.....	.....	.....	.....
Iowa	(a)	.....	.....	.....	.....	.....	.....
Kansas	(a)	.....	.....	(a)	(a)	(a)	.....
Kentucky	4,721	61,045	.....	.....	.....	.....	.....
Maryland	(a)	.....	(a)	.....	.....	.....	(a)
Massachusetts	58,328	(a)	.....	.....	.....	.....	(a)
Michigan	(a)	(a)	.....	.....	.....	.....	(a)
Minnesota	(a)	(a)	.....	(a)	(a)	.....	(a)
Missouri	(a)	(a)	.....	.....	.....	.....	(a)
Montana	(a)	(a)	.....	.....	.....	.....	.....
Nebraska	(a)	(a)	.....	.....	.....	.....	.....
New Jersey	28,239	3,475	.....	(a)	.....	.....	(a)
New Mexico	.....	.....	.....	.....	.....	.....	(a)
New York	35,955	149,016	.....	131,430	221,060	37,987	(a)
North Carolina	.....	.....	.....	.....	.....	.....	.....
Ohio	126,626	369,091	(a)	.....	375,690	308,516	9,016
Oklahoma	(a)	(a)	.....	(a)	.....	.....	(a)
Oregon	.....	.....	.....	.....	.....	.....	.....
Pennsylvania	102,398	114,827	410,541	78,237	86,061	41,829	25,033
South Dakota	2,127	(a)	(a)	(a)	.....	.....	(a)
Tennessee	.....	.....	.....	.....	.....	.....	.....
Texas	.....	.....	.....	.....	.....	.....	(a)
Utah	(a)	(a)	.....	(a)	.....	.....	(a)
Virginia	.....	.....	.....	.....	.....	.....	.....
Washington	(a)	(a)	.....	(a)	.....	.....	(a)
West Virginia	4,448	3,939	.....	(a)	(a)	(a)	3,910
Wisconsin	8,551	21,683	79,643	23,266	(a)	(a)	5,924
Wyoming	(a)	(a)	.....	.....	.....	.....	.....
Undistributed	65,659	142,448	39,621	83,653	19,088	541	37,732
	447,921	868,366	529,805	327,264	702,902	389,859	86,938

a Included in "Undistributed."

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Value of sandstone (including quartzite and bluestone) produced and sold in the United States, 1915–1916—Continued.

1916—Continued.

State.	Riprap.	Crushed stone.			Other.	Total.
		Road metal.	Railroad ballast.	Concrete.		
Alabama	(a)					$20,995
Arizona					(a)	(a)
Arkansas	(a)	(a)	(a)	$14,071	(a)	95,398
California	$106,532	$137,814	$23,145	145,655		422,225
Colorado	2,022		(a)	(a)	(a)	53,902
Connecticut	(a)				(a)	(a)
Idaho					(a)	47,061
Illinois		(a)	(a)			40,343
Iowa					(a)	(a)
Kansas				600		3,495
Kentucky	40,500	(a)		(a)	(a)	114,136
Maryland		(a)		(a)		6,003
Massachusetts		53,600		190,914	(a)	318,982
Michigan	(a)	(a)		(a)		21,449
Minnesota		(a)		66,668	(a)	186,179
Missouri	(a)				(a)	14,991
Montana						5,362
Nebraska	(a)				(a)	(a)
New Jersey	(a)	(a)		(a)	(a)	46,035
New Mexico	(a)			16,860		18,330
New York	1,392	70,008	10,397	44,150	$12,825	714,558
North Carolina			(a)	(a)	(a)	(a)
Ohio	63,685	7,275		(a)	8,391	1,274,181
Oklahoma				(a)	(a)	24,229
Oregon	(a)					(a)
Pennsylvania	18,801	160,090	107,548	115,438	57,436	1,318,289
South Dakota	5,117	(a)		124,914	(a)	163,735
Tennessee					(a)	(a)
Texas	62,850	(a)		(a)		85,940
Utah						27,207
Virginia		53,800	(a)			66,217
Washington	(a)					(a)
West Virginia	(a)	8,655	(a)	17,356	(a)	48,416
Wisconsin	8,714	30,729		9,897	(a)	188,791
Wyoming	(a)			(a)		(a)
Undistributed	177,162	107,732	39,045	108,303	18,503	262,741
	488,874	629,703	180,135	854,856	97,155	5,608,778

a Included in "Undistributed."

Building stone.—After decreasing in value 3 per cent in 1914 and 22 per cent in 1915, sandstone decreased $100,555, or 7 per cent, in 1916. This decrease was wholly in dressed stone, which offset a small gain ($15,729) in rough stone. In 1915, on the other hand, rough stone accounted for about two-thirds of the total decrease. Ohio, Pennsylvania, and New York continued to be the only States whose total value of building stone exceeded $100,000, and in each of these States the value of dressed stone exceeded that of rough stone. Ohio, with the value of rough stone nearly doubled in 1916, was, as in 1915, the only one of these States to show gain in total building stone. Massachusetts, also, made a noteworthy increase, mostly in value of rough stone, and Kentucky showed a small gain in the value of dressed stone in spite of a railroad embargo that closed one of its principal markets (the Eastern States) for three months. Improved demands were also reported by important producers in Minnesota and Idaho. The principal decrease among the moderately important States was in West Virginia, whose value of dressed stone decreased from $30,898 to $3,939, mainly because of the idleness of quarries at Kingwood.

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Ganister.—Ganister was brought into marked prominence during 1915 and 1916 by the unusual activity of furnaces. The marketed production of this material in 1916 was 859,956 short tons, valued at $529,805, about 62 cents a ton. This was an increase of 50 per cent in quantity, 58 per cent in value, and 3 cents in average price per ton, compared with 1915, which had shown substantial increase compared with 1914.

Ganister is a quartzite or a sandstone in which silica has filled the spaces between the original quartz grains and cemented the rock into a compact mass. It is broken to the size of ordinary crushed stone, then ground finely and mixed with sufficient lime to form a bond, and thus made into silica brick. This brick is used to line the sides and crowns of open-hearth steel furnaces, by-product coke ovens, continuous glass furnaces, and any furnaces which require a highly refractory brick and in which the brick do not come into contact with material that would flux them.

Ganister rock was quarried in Alabama, Colorado, Illinois, Maryland, Ohio, Pennsylvania, South Dakota, and Wisconsin in 1916. Pennsylvania and Wisconsin, as usual, were the chief producing States. Pennsylvania's output was 675,424 short tons (79 per cent of the total), valued at $410,541, and Wisconsin's was 137,577 short tons, valued at $79,643. Blair and Huntington counties furnished most of the stone quarried in Pennsylvania, and quarries near Devils Lake, Sauk County, furnished most of that quarried in Wisconsin. Many manufacturers of silica brick or refractory products quarry their own stone.

Paving.—Paving, after decreasing $23,075 in 1914 and $180,912 in 1915, showed an additional decrease of $205,516, or 38 per cent, in 1916. New York, the leading State, accounted for nearly two-thirds of this decrease, its loss of $128,493 following a loss of $101,927 in 1915. Pennsylvania, the second State, after an increase of $69,028 in 1915, fell below the $100,000 mark with a loss of $34,896. Wisconsin, which ranked third in 1915, decreased 58 per cent in value in 1916. This continued decrease is due mainly to competition with other materials and to lack of demand in Canada during the war. It may be attributed also to the fact that sandstone blocks were not laid in former years with the care demanded in present specifications for paving blocks and have shown correspondingly poor results. Well-selected sandstone blocks laid according to these specifications should have much in their favor for use on streets of heavy traffic, except those of extremely heavy traffic where only well-cut granite and basalt or diabase (trap rock) blocks are satisfactory.

Curbing and flagging.—Curbing and flagging are two important sandstone products whose decreased use, owing to competition with concrete, accounts in large measure for the decline in total value of sandstone. Curbing, after decreasing $166,519 in 1914 and $97,853 in 1915, showed a further decrease of $187,562, or 22 per cent, in 1916. Only three States, Ohio, New York, and Pennsylvania, are important producers of curbing and all showed marked decrease in 1916. The greater part of the curbing sold in New York and Pennsylvania was, as usual, bluestone, but the predominance of this stone was not so marked as in former years.

Flagging also continued its steady decrease in value, declining $79,918, or 25 per cent, in 1916. Ohio, the only very important

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State, showed a decrease of $32,330 in 1916, following a decrease of $13,629 in 1915. New York, the second State, whose value in 1915 decreased $41,849 and fell below $100,000 for the first time in many years, showed an additional decrease of $32,178, or 46 per cent, in 1916. Pennsylvania, the third State, also showed a marked decrease in 1916. Practically all of this flagging sold in New York and Pennsylvania is bluestone.

Rubble and riprap.—Rubble, after a gain of $51,182 in 1915, declined $70,150, or 45 per cent, in 1916. New Mexico gained the lead in 1915 and decreased to insignificance in 1916, leaving Pennsylvania the only State whose value exceeded $20,000. Riprap, after decreasing $451,310 in 1915, increased $126,724, or 35 per cent, in 1916. This increase was due mainly to "other" States, most important of which was Oregon, where there was a large demand for riprap. Arkansas, California, and Kentucky also showed considerable increase, and New Mexico and Pennsylvania showed the largest decrease.

Crushed stone.—Crushed sandstone in 1916 for the second year in succession showed decrease in sales—11 per cent in quantity and 10 per cent in value. The largest decrease was in crushed stone for concrete. Road metal and railroad ballast, after increasing in 1915, both also decreased in 1916. Some of the rocks included here, such as the Roxbury conglomerate or "puddingstone" in Massachusetts and the argillite in Pennsylvania, are very different in character from sandstone, though more appropriately grouped with it than with any of the other classes of stone considered in this report. They should preferably be put in a group of miscellaneous stone, and it is hoped that this new arrangement can be followed in the report for 1917.

Other uses.—Sandstone for "other" uses increased $15,801, or 19 per cent, in 1916, after a large decrease of $267,194 in 1915. About half of the value in 1916 was represented by mica schist quarried in eastern Pennsylvania for furnace lining. The output of this stone sold in 1916 was 33,236 short tons, valued at $47,304. It is expected that this stone also will be placed in the miscellaneous group in the report for 1917.

BLUESTONE.

The figures of production for bluestone in the following tables are included in those of sandstone, but on account of the local importance of the stone are also given separately. The value in 1916 showed a continuation of the decrease that has been steady since 1911 and was the smallest recorded since statistics have been collected by the Survey; it represented a decrease of 21 per cent compared with 1915, in which the decrease was 41 per cent.

Value of bluestone produced and sold in the United States, 1909–1916.

Year.	Value.	Year.	Value.
1909	$1,446,402	1913	$1,280,382
1910	1,535,187	1914	1,086,699
1911	1,876,473	1915	641,446
1912	1,505,763	1916	510,011

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Value of bluestone produced and sold in New York and P

State.	Building purposes.	Flagging.	Curbing.
1915.			
New York	$170,316	$69,962	$112,184
Pennsylvania	43,082	57,455	54,923
	208,398	112,317	152,107
1916.			
New York	168,834	37,487	132,486
Pennsylvania	31,060	41,729	48,415
	199,894	79,216	180,901

The quarrying of this stone, which at one t
able industry, has been steadily decreasing. T
years used largely as curbstone and flagstone
buildings, such as sills, lintels, steps, and ba
these uses has now been considerably replace
and artificial stone. This "bluestone" was u
in the concrete and heavy masonry work of th
supply system, and the completion of this
great decrease in the demand for it during the
The demand for heavy curbing in 1916 w
that for all other uses, as shown in the prece
encouraging. There was great difficulty in
unskilled laborers usually employed in stripp
away by the attractive wages offered by the

CRUSHED STONE.

GENERAL STATISTICS

Crushed stone, as is shown by the following t
been the largest factor in the stone industry

Value of exterior building stone, monumental stone, and cru
States, 1898–1916.

Year.	Monumental stone (rough and dressed).	Building stone (rough and dressed).	Crushed stone.	Year.	Monume stone (ro and dress
1898	$3,076,340	$13,014,596	$4,031,445	1908	$6,948,
1899	3,338,122	[a] 15,870,676	4,692,343	1909	6,104,
1900	3,618,316	15,578,009	6,525,368	1910	6,887,
1901	4,734,699	17,583,102	8,560,432	1911	6,985,
1902	5,941,585	20,790,341	11,480,959	1912	6,759,
1903	5,767,360	19,795,491	13,188,938	1913	7,212,
1904	5,991,714	18,883,455	15,530,122	1914	7,150,
1905	6,112,585	20,240,809	16,419,614	1915	[a] 6,459,
1906	6,773,478	20,681,625	17,467,486	1916	7,031,
1907	6,978,949	16,675,811	22,054,297		
Percentage of increase or decrease in 1916					+

[a] Revised.

The total quantity of crushed stone sold in 1
cent less than in 1915, but the value was 1 pe
to an increase of 1 cent in average price per ton
however, reported increase of 10 to 25 cents a t

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cost of operation. The value in 1916 was less than in either 1914 or 1913, the record year, and the quantity showed continuation of a decrease that has been steady since 1913. Competition with gravel and in a few places with furnace slag is reported by some as an important cause of this decline.

The distribution of crushed stone in 1916 according to kinds of stone and uses is shown in the following table:

Crushed stone produced and sold in the United States in 1915 and 1916, by kinds of stone.

Kind.	Road metal.		Railroad ballast.		Concrete.		Total.		Average price per ton.
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	
1915.									
Granite	2,299,046	$1,664,218	1,197,437	$693,996	1,742,718	$1,465,560	5,239,201	$3,823,774	$0.73
Basalt and related rocks (trap rock)	4,790,092	3,216,107	1,947,715	1,194,873	3,034,030	1,966,661	9,771,837	6,377,641	.65
Limestone	14,608,471	8,164,230	7,894,323	3,604,256	9,082,914	5,334,509	31,575,708	17,102,995	.54
Sandstone	1,012,461	690,991	338,566	205,769	1,070,934	952,318	2,421,961	1,849,078	.76
	22,710,070	13,735,546	11,368,041	5,698,894	14,930,596	9,739,048	49,008,707	29,173,488	.....
Average price per ton	.....	$0.60	.....	$0.50	.....	$0.65	.....	$0.60	.....
1916.									
Granite	1,478,235	1,179,950	1,158,518	581,339	2,086,552	1,782,121	4,723,305	3,543,416	.75
Basalt and related rocks (trap rock)	4,268,000	3,192,694	1,101,958	761,320	3,638,416	2,585,064	9,008,374	6,539,008	.73
Limestone	13,245,634	7,417,384	8,088,673	3,650,647	10,849,729	6,647,803	32,184,036	17,715,834	.55
Sandstone	832,893	629,703	305,866	180,135	1,021,107	854,856	2,159,866	1,664,694	.77
	19,824,762	12,419,667	10,655,015	5,173,441	17,595,804	11,869,844	48,075,581	29,462,952	.....
Average price per ton	.....	$0.63	.....	$0.49	.....	$0.67	.....	$0.61	.....
Percentage of increase or decrease in 1916	−12.7	−9.6	−6.7	−9.2	+17.9	+21.9	−1.9	+1.00	.....

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Crushed stone sold in the United States in 1915 and 1916, by States and Territories.

1915.

State or Territory.	Road metal.		Railroad ballast.		Concrete.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	49,972	$42,116	2,200	$554	77,705	$45,443	129,877	$88,113
Arizona	.....	.....	14,462	7,173	1,250	2,000	15,712	9,173
Arkansas	113,606	75,044	83,685	55,493	105,736	72,209	303,027	202,746
California	1,567,505	902,462	661,679	302,261	1,589,231	917,507	3,818,415	2,122,230
Colorado	5,842	7,178	3,750	2,200	19,189	22,171	28,781	31,549
Connecticut	728,014	330,174	265,720	131,055	434,307	221,052	1,428,041	682,281
Delaware	21,742	21,707	11,088	11,770	24,929	25,296	57,759	58,773
Florida	102,517	56,381	125,000	50,000	96,407	108,003	323,924	214,384
Georgia	90,244	54,696	33,907	26,136	113,746	95,983	237,897	176,815
Hawaii	34,413	36,366	15,051	15,000	49,489	67,176	98,953	118,542
Illinois	1,625,250	747,718	814,443	341,126	2,196,083	1,072,268	4,635,776	2,161,112
Indiana	1,792,261	910,462	150,047	55,649	65,325	33,262	2,007,633	999,373
Iowa	32,437	28,397	187,978	78,886	417,866	261,799	638,281	369,082
Kansas	20,046	15,591	327,496	169,117	296,766	222,524	644,308	407,232
Kentucky	609,995	379,234	769,886	327,578	132,233	78,952	1,512,114	785,764
Louisiana	330	664	7,907	6,326	17,921	14,337	26,158	21,327
Maine	1,747	1,409	3,132	2,349	5,551	4,123	10,430	7,881
Maryland	334,153	274,644	375,172	240,899	236,727	189,370	946,052	704,913
Massachusetts	738,015	599,555	140,638	72,068	506,350	434,132	1,385,003	1,105,775
Michigan	510,524	224,734	60,455	19,684	417,723	239,351	988,702	483,769
Minnesota	59,733	57,286	.....	.....	348,059	271,753	407,792	329,039
Missouri	553,049	383,022	167,319	82,005	658,874	519,050	1,379,242	984,077
Montana	28,875	5,186	809	178	16,750	8,303	41,434	13,667
Nebraska	.....	.....	26,913	11,913	281,866	249,269	308,779	261,182
New Hampshire	14,845	12,416	.....	.....	14,767	11,001	29,612	23,417
New Jersey	1,059,749	822,214	385,000	260,426	363,513	297,626	1,808,262	1,380,266
New Mexico	547	407	8,000	4,800	159,375	225,950	167,922	231,157
New York	2,900,165	1,623,570	1,277,228	700,255	1,591,393	982,736	5,768,786	3,306,561
North Carolina	69,238	73,404	163,815	92,026	357,934	308,047	590,987	473,477
Ohio	3,088,599	1,567,676	1,453,243	603,599	979,973	464,268	5,521,815	2,635,543
Oklahoma	46,430	29,764	459,107	205,765	208,253	133,232	713,790	368,761
Oregon	290,648	202,580	182,197	80,433	222,039	151,399	694,884	434,412
Pennsylvania	1,844,626	1,218,446	1,139,340	732,073	1,149,076	751,391	4,133,042	2,701,910
Rhode Island	91,872	110,167	.....	.....	83,750	109,730	175,622	219,897
South Carolina	27,111	26,566	50,714	49,678	125,981	117,070	203,806	193,314
South Dakota	11,292	8,487	.....	.....	108,850	86,415	120,142	94,902
Tennessee	441,298	369,296	395,740	132,655	144,498	86,027	981,536	587,978
Texas	289,151	164,865	60,607	31,212	373,344	263,307	703,102	459,384
Utah	6,500	3,750	1,500	750	5,621	2,810	13,621	7,310
Vermont	14,929	13,269	156	125	7,514	7,374	22,599	20,768
Virginia	2,193,898	1,538,149	933,317	507,966	255,716	140,003	3,382,931	2,186,118
Washington	213,039	111,461	3,120	2,388	470	500	216,629	114,349
West Virginia	196,068	129,106	535,712	251,503	74,711	50,412	806,491	431,021
Wisconsin	914,295	555,927	70,508	33,800	584,252	366,257	1,569,055	955,984
Wyoming	.....	.....	.....	.....	9,383	8,160	9,383	8,160
	22,710,070	13,735,546	11,368,041	5,698,894	14,930,596	9,739,048	49,008,707	29,173,488

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Crushed stone sold in the United States in 1915 and 1916—Continued.

1916.

State or Territory.	Road metal.		Railroad ballast.		Concrete.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama	(a)	(a)	(a)	(a)	71,990	$41,321	74,381	$42,699
Arizona	(a)	(a)	(a)	(a)	28,679	27,001	105,243	69,826
Arkansas	122,483	$90,030	156,095	$76,838	173,371	117,519	451,949	284,387
California	1,092,374	648,444	495,807	221,227	1,632,783	899,483	3,220,964	1,769,154
Colorado	(a)	(a)	(a)	(a)	25,807	27,564	31,445	31,661
Connecticut	577,127	334,207	77,950	45,856	635,667	395,064	1,290,744	775,127
Delaware	(a)	(a)			(a)	(a)	(a)	(a)
Florida	277,556	139,474	93,750	42,000	132,789	153,795	504,095	335,269
Georgia	126,344	86,780	41,589	29,028	202,165	169,301	370,098	285,109
Hawaii	69,481	72,673			111,925	151,132	181,406	223,805
Idaho					(a)	(a)	(a)	(a)
Illinois	1,952,065	852,343	991,788	392,440	2,565,001	1,228,533	5,508,854	2,473,616
Indiana	1,542,122	810,719	218,866	73,078	167,031	86,359	1,928,019	970,156
Iowa	14,201	11,374	155,669	76,929	541,093	342,082	710,963	430,385
Kansas	113,222	64,329	220,772	143,763	235,042	232,344	569,036	440,436
Kentucky	990,342	645,963	832,742	355,564	76,907	52,893	1,899,991	1,054,420
Louisiana	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Maine	4,173	3,702	(a)	(a)	(a)	(a)	13,575	11,270
Maryland	250,095	232,681	330,388	216,840	202,133	167,804	782,616	617,325
Massachusetts	588,927	565,761	13,402	10,862	493,366	480,682	1,095,695	1,057,305
Michigan	876,099	461,576	187,194	57,985	336,772	168,433	1,400,065	687,994
Minnesota	65,119	63,833	18,352	10,799	504,775	437,756	588,246	512,388
Missouri	298,418	237,030	123,445	65,525	661,516	585,428	1,083,379	887,983
Montana b	11,269	6,151			25,096	9,291	39,240	16,138
Nebraska	(a)	(a)	(a)	(a)	335,820	290,103	362,005	299,093
New Hampshire b	18,600	16,233					25,596	22,431
New Jersey	1,019,027	882,119	243,650	180,636	352,279	307,171	1,614,956	1,369,926
New Mexico b					17,443	16,860	101,243	75,520
New York	2,258,471	1,414,912	978,832	552,840	1,890,180	1,249,847	5,127,483	3,217,599
North Carolina	100,376	95,337	131,617	72,717	682,604	609,377	914,597	777,431
Ohio	3,166,136	1,604,559	1,510,411	612,336	1,685,023	822,158	6,361,570	3,039,053
Oklahoma	36,960	21,110	623,902	336,484	209,738	141,327	870,600	498,921
Oregon	233,708	156,414	95,514	21,031	90,542	68,522	419,759	245,967
Pennsylvania	1,517,871	1,084,698	864,222	576,154	1,109,696	825,079	3,491,789	2,485,931
Rhode Island	93,425	118,781			54,187	82,484	147,612	201,265
South Carolina	55,344	47,635	21,469	15,160	311,061	217,807	387,874	330,602
South Dakota	7,350	6,300			155,076	132,116	162,426	138,416
Tennessee	430,880	311,739	489,625	124,514	194,600	96,165	1,115,105	532,418
Texas	85,710	62,179	64,825	30,259	473,017	319,651	623,552	412,089
Utah	(a)	(a)			(a)	(a)	(a)	(a)
Vermont	7,642	5,859			7,024	8,818	14,666	14,677
Virginia	585,528	443,121	988,971	492,169	238,750	155,117	1,813,249	1,090,407
Washington	149,452	81,380			5,257	3,156	154,709	84,536
West Virginia	300,390	189,210	390,630	179,413	108,028	68,886	799,048	437,509
Wisconsin	754,379	522,368	113,754	61,112	702,505	507,638	1,570,638	1,091,118
Wyoming					(a)	(a)	(a)	(a)
Undistributed	32,101	28,643	179,784	99,882	149,066	123,477	147,100	121,570
	19,824,762	12,419,667	10,655,015	5,173,441	17,595,804	11,869,844	48,075,581	29,462,952

a Included in "Undistributed."
b Small quantities not classified included in "Undistributed."

Limestone, which has supplied by far the greatest proportion of crushed stone since the Survey's statistics have been collected (fig. 23), increased in both quantity and value, and its average price per ton increased 1 cent. Basalt and related rocks decreased in quantity but increased in value, the average price per ton increasing 8 cents. Granite and sandstone decreased in both quantity and value, although their average prices per ton increased 2 cents and 1 cent respectively.

Road metal decreased about 13 per cent in quantity and 10 per cent in value, although its average price per ton, 63 cents, marked a gain of 3 cents, compared with 1915. Railroad ballast decreased about 7 per cent in quantity and 9 per cent in value, its average price per ton, 49 cents, decreasing 1 cent. Stone for concrete

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increased about 18 per cent in quantity and 22 per cent in value, its average price per ton increasing from 65 cents in 1915 to 67 cents in 1916. As may be inferred from these statements, the greatest gain in any one item was in limestone for concrete—1,766,815 short tons in quantity and $1,313,294 in value. Granite and basalt for concrete also increased in both quantity and value, and this general increase was in keeping with the marked increase in shipments of Portland cement, reported in a preceding chapter, and with the large amount of rapid construction during 1916, which called for concrete rather than for natural stone. Owing to this demand the total value of crushed stone sold for concrete in 1916 slightly exceeded that of exterior building stone and approached rather near that of crushed stone for road metal, which has always been the leading product.

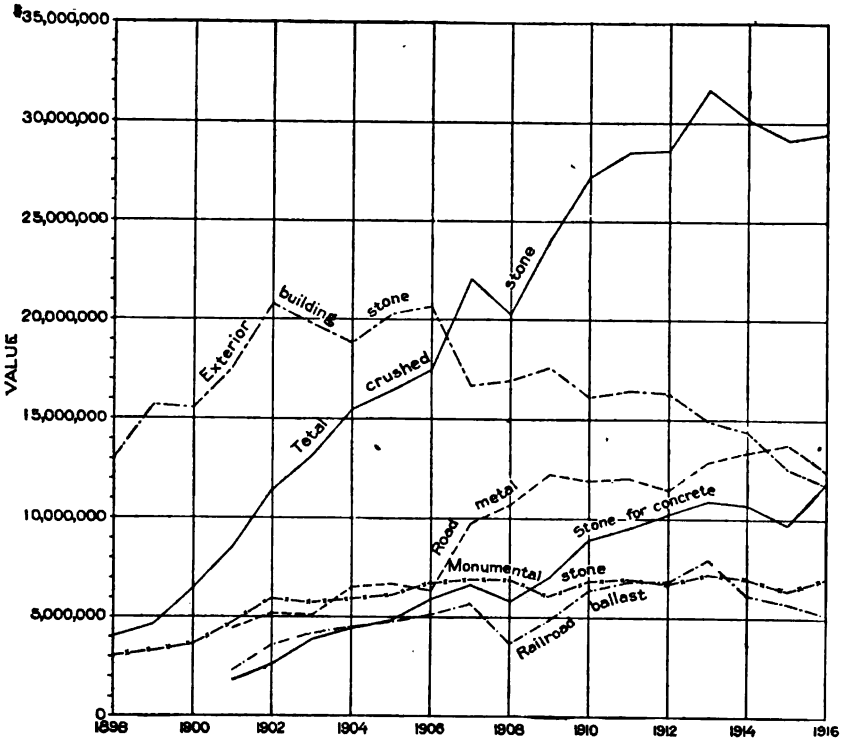

FIGURE 22.—Diagram comparing values of crushed stone with those of stone for exterior building and for monumental use; also showing value of crushed stone for different uses, 1898 to 1916, inclusive.

In addition to crushed stone for roads, railroads, and concrete, there were sold for the same purposes in 1916, 32,477,927 tons of gravel, valued at $10,440,857, and 3,998,548 tons of sand, valued at $1,426,053. Railroads also reported production for their own use of 13,649,827 tons of sand and gravel, valued at $1,779,289. These products are discussed in detail in the chapter on sand and gravel. In southwestern and southeastern Missouri a considerable quantity of railroad ballast and road metal is obtained from the tailings of the concentrating mills at zinc mines, which is put on the market as "chats" and consists of small angular fragments of chert and

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limestone. The zinc companies are glad to dispose of this waste material, which in normal times has been loaded on the cars by the railroads of the district at a cost of 6 or 8 cents a ton. It sells at distant points of delivery at prices ranging from 50 cents to $1 a ton. In the neighborhood of the mines, however, the selling price has been about 15 cents a ton, and the average price of total sales has also been about 15 cents.

"Chats" sold in Missouri in 1914, 1915, and 1916.

	Railroad ballast (short tons).	Other uses (short tons.)	Total (short tons).	Value.
1914	1,687,331	583,440	2,270,771	$340,616
1915	1,713,884	595,307	2,309,191	346,379
1916	2,268,370	622,600	2,890,970	433,646

According to H. A. Buehler, State geologist of Missouri, 2,257,452 short tons were shipped from southwestern Missouri, and 633,518 short tons from southeastern Missouri in 1916. Besides "chats" one company in southeastern Missouri sells large-sized stone waste from mine shafts for railroad ballast and as stone suitable for concrete.

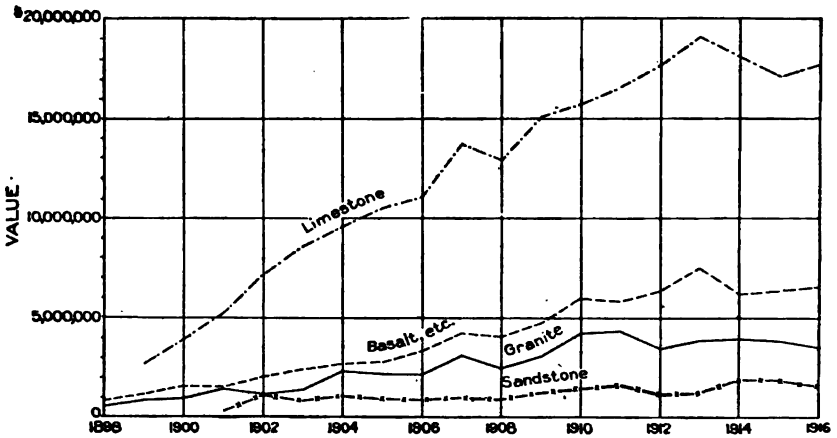

FIGURE 23.—Diagram showing values of limestone, basalt, granite, and sandstone sold as crushed stone, 1898 to 1916, inclusive.

In Florence County, Wis., a small quantity of taconite, or "iron ore rock," obtained from mine dumps was used as road metal.

In Tennessee and Alabama a quantity of chert has been used for road metal. Crushed slag from one or both of these States, as well as from Pennsylvania, has been used for the same purpose, as well as for railroad ballast, concrete, and roofing material.

In California a small quantity of volcanic ash, weighing 2,400 pounds per cubic yard, was used as railroad ballast.

According to the table on page 1070, 15 States exceeded 1,000,000 tons in quantity and 10 exceeded $1,000,000 in value of crushed stone sold in 1916, compared with 13 and 8 States, respectively, in 1915. Michigan and Tennessee passed the 1,000,000-ton mark, and

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Kentucky and Wisconsin passed the $1,000,(which led in both quantity and value in 191 value, but was third in quantity in 1916. Ohio to first in quantity, and from third to second vanced from third to second in quantity, and value. Of the other changes in rank of the 10 l conspicuous were Kentucky's rise from ninth t tity, Virginia's drop from fourth to eighth pl consin's rise from eleventh to seventh place in v Michigan, and Minnesota joined the States value in 1916.

Twenty-three of the 45 producing States sho tity, and 24 increased in value, Kansas and W in quantity and increasing in value, and Te quantity and decreasing in value. Idaho, no furnished stone for concrete in 1916. Of the m those in the East and the West (New York, P sey, Virginia, Massachusetts, Connecticut, fornia) showed decrease in output, while the Illinois, Wisconsin, Kentucky, Michigan, and increase. Exceptions to this grouping were N showed increase, and Indiana and Missouri, wh Among the less important States, however, the whole increased their output, while the Middl were about equally divided as regards increase

WEIGHT OF CRUSHED STONE PER C

Inquiries have been received by the Survey particularly from associations interested in co the testing of materials regarding the weight crushed stone per cubic yard. The following been compiled from reports by producers. The by kinds of rock and, second, by States, counti

GRANITE.

	Pounds.
Arizona:	
Yuma County, Dome	2,650
California:	
Humboldt County, Arcata	2,700 2,800
Kern County, Woodford	2,875
Riverside County, Corona	2,400
San Benito County, Watsonville	2,500
Colorado:	
Boulder County, Scenic	2,350
Delaware:	
New Castle County, Greenbank	2,800
Georgia:	
Dekalb County, Lithonia	2,500
Fulton County, Atlanta	2,500
Idaho:	
Bonneville County, Idaho Falls	3,000
Maryland:	
Baltimore City	2,500
Baltimore County:	
Gardenville	2,700
Woodberry	2,700

GRA

Massachusetts:	
Essex Cou	
Norfolk C	
Colony	
Worcester	
New Jersey:	
Morris Co	
New York:	
Fulton Co	
Herkimer	
Jefferson	
Bay	
Westches	
Golde	
Valha	
North Carolin	
Mecklenb	
lotte	
Vance Co	
Grey	
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GRANITE—continued.

	Pounds.
Oregon:	
Josephine County, Granite	2,750
Pennsylvania:	
Berks County, Barto	2,430
Montgomery County, Bryn Athyn	2,646
Philadelphia County, Holmesburg	2,700
Rhode Island:	
Newport County, Newport	2,700
Providence County, Cranston	2,586
South Carolina:	
Anderson County, Williamston	2,600
Richland County, Columbia	2,500
Virginia:	
Campbell County, Lone Jack (5 miles below Lynchburg)	2,300
Fairfax County:	
Herndon	2,700
Occoquan	2,700
Goochland County, Boscobel	2,500
Washington:	
King County, Northbend	2,600
Wisconsin:	
Green Lake County:	
Berlin	2,600
Utley	2,600
Lincoln County, Tomahawk	3,000
Marathon County, Knowlton	2,700
Waupaca County, Waupaca	2,800 2,600
Waushara County:	
Lohrville	2,600
Redgranite	2,600

BASALT AND RELATED ROCKS (TRAP ROCK).

Arkansas:	
Pulaski County, Little Rock	2,300
California:	
Alameda County, Berkeley	2,500
Contra Costa County:	
Richmond	2,500 2,700
Stege	2,700
Point Richmond	2,700
Fresno County, Reedley (Piedra)	2,600
Humboldt County, Eureka quarry	2,650
Marion County, San Rafael	2,350
Napa County, Napa	2,400 2,500
San Mateo County:	
South San Francisco	2,700
Daly City	2,460
San Mateo	2,500
San Francisco County, San Francisco	3,000
Santa Clara County, Saratoga	2,800
Sonoma County:	
Petaluma	2,800
Santa Rosa	2,700

BASALT AND RELATED ROCKS (TRAP ROCK)—continued.

Hawaii:	
Moilili	2,700
Honolulu	2,500 2,400
Hilo	2,500
Waipahu and Aria	2,350
Idaho:	
Bonneville County, Idaho Falls	3,000
Massachusetts:	
Middlesex County, Newton	2,800
Suffolk County, Brighton	2,600
Michigan:	
Dickinson County	2,750
Marquette County:	
Negaunee	2,700
Marquette	2,500
Ontonagon County, Bergland	2,800
Minnesota:	
Lake County, Two Harbors	2,600 2,750 2,400
St. Louis County, Duluth	2,600
New Jersey:	
Bergen County:	
Cliffside Park	2,750
Englewood	2,700
Hudson County:	
North Bergen	2,700
Secaucus	2,650 2,700
Union County, Hopewell	2,700
Passaic County:	
Great Notch	2,640 2,650
Little Falls	2,750
Paterson	2,750 2,700 2,630
Richfield	2,500
Prospect Park (Valley Road quarry)	2,650
Prospect Park (Prospect Park quarry)	2,650
Somerset County:	
Bernardsville	2,600 2,900
Far Hills	2,800
New York:	
Queens County, Richmond Hill	2,650
Rockland County, Rockland Lake	2,500
Oregon:	
Clatsop County, Astoria	2,500
Columbia County, St. Helens	3,000 2,700
Marion County, Marion	2,700
Multnomah County:	
Latourell	2,700
Crusher	2,800
Portland	2,650

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BASALT AND RELATED ROCKS (TRAP ROCK)—continued.

	Pounds.
Oregon—Continued.	
Polk County, Falls City	2,800
Tillamook County, Enright	2,750
Wasco County, Mosier	2,600
Washington County	2,700
Yamhill County, Carlton	2,800
Pennsylvania:	
Chester County, Cornog Station	2,400
Cumberland County, West Fairview	2,400
Montgomery County, Green Lane	2,450
Washington:	
Clarke County:	
Yacolt	2,800
No. 1	3,000
No. 2	2,830
No. 3	2,700
Average	2,842
Cowlitz County, Mount Coffin quarry, 4 miles from Kelso	2,416
King County, Riverton	2,150
Lewis County, Meskill	2,566
	2,450
	2,600
Walla Walla County, Dixie	2,566
Yakima County, North Yakima	2,500

LIMESTONE.

Alabama:	
Franklin County, Rockwood	2,400
Jackson County, Bridgeport	2,800
Madison County, Huntsville	2,750
Arkansas:	
Sharp County, Williford	2,400
Florida:	
Citrus County, Crystal River	2,200
Dade County:	
Naranja	2,000
Ojus	2,500
Hernando County, Riverland	1,800
Levy County, Montbrook	1,900
Manatee County, Manatee	2,230
Marion County:	
Dunellon	1,800
Ocala	1,800
Georgia:	
Bartow County, Cartersville	2,350
Illinois:	
Adams County, Quincy	2,500
Boone County, Belvidere	2,500
Clark County, Casey	2,750
Cook County:	
Chicago	2,500
La Grange	2,500
Lyons	2,500
Thornton	2,500
Crawford County, West York	2,700
Dupage County, Elmhurst	2,500
Jersey County, Grafton	2,330
Jo Daviess County, Stockton	2,500
Kane County, Batavia	2,500

LIMES

Illinois—Cont
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Whiteside
Will Coun
Winnebag
Rockf
Shirla
Indiana:
Adams Cou
Bartholom
Clark Coun
Decatur Co
Howard Co
Jefferson C
Monroe Cou
Newton Co
Ripley Cou
Sullivan Co
Wabash Cou
Iowa:
Blackhawk
Clayton Cou
McGreg
North
Dubuque C
Howard Cou
Jones Count
Anamos
Stone C
Lee County
Keokuk
Montros
Linn Count
Cedar R
Mount
Madison Cou
Marshall Co
Scott Count
Bettend
Buffalo
Linwood
Le Clair
Kansas:
Allen Count
Bourbon Cou
Cowley Coun
Douglas Cou
Johnson Cou
Labette Cou
Marion Coun
Morris Count
Neosho Coun
Nelson Count

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LIMESTONE—continued.

	Pounds.
Kansas—Continued.	
Wyandotte County:	
Morris	2,300
Rosedale	2,400
Kentucky:	
Bourbon County, Paris	2,400
Caldwell County, Princeton	2,250
Campbell County, Newport	2,700
Carter County:	
Carter	2,280
Lawton	2,480
Olive Hill	2,328 2,250 2,400
Christian County, Hopkinsville	2,200 2,300 2,400
Clark County, Winchester	2,430
Fleming County, Flemingsburg	2,560
Hardin County, Stephensburg	2,400
Jefferson County:	
Anchorage	2,700
Buechel	2,400
Blankenbaker Station	2,400
Tuckers Station	2,400
Jessamine County:	
Highbridge	2,400
Wilmore	2,300
Kenton County, Covington	3,000 2,500
Lagrange County, Carlisle	2,300
Lee County, Yellow Rock:	
Railroad ballast	2,364
Screening	2,383
Concrete	2,364
Lincoln County, Stanford	2,500
Logan County:	
Russellville	2,300
Auburn	2,400
Mercer County, Harrodsburg	2,200
Nicholas County:	
Blue Lick Springs	2,800
Carlisle	2,400
Owen County	2,160
Rockcastle County:	
Mount Vernon	2,300
Burr	2,300
Withers	2,300
Spencer County	2,250
Todd County, Daysville	2,400
Washington County, Springfield	2,300
Maryland:	
Washington County, Hagerstown	2,500
Michigan:	
Delta County:	
Groos	2,600
Manistique	2,700
Minnesota:	
Blue Earth County, Mankato	2,400
Dakota County, Mendota	2,400
Hennepin County, Minneapolis	2,400 2,079 3,000

LIMESTONE—continued.

	Pounds.
Minnesota—Continued.	
Lesueur County, Kasota	2,500
Ramsey County, St. Paul	2,400
Winona County, Stockton	2,400
Missouri:	
Andrew County:	
Amazonia	2,200 2,300
Savannah	2,300 2,400
Shuster	2,350
Boone County, Columbia	2,500
Buchanan County, St. Joseph	2,400 2,600
Caldwell County, Breckenridge	2,350
Cape Girardeau County:	
CapeGirardeau	2,300
Jackson	2,300
Cole County, Jefferson City	2,400 2,500
Cooper County, Sweeney	2,670 2,660
Daviess County, Gallatin	2,600 2,500
Greene County	2,250
Springfield	2,400 2,440
Harrison County, Bethany	2,430
Holt County, Oregon	2,450
Jackson County:	
Independence	2,350
Kansas City	2,250, 2,300, 3,000, 2,200, 2,100, 2,350
Leeds	2,350
Ray County:	
Richards	2,700
Richmond	2,700
St. Charles County, St. Peters	2,400
St. Genevieve County, Brickeys	2,350
St. Louis County, Fern Ridge	2,500 3,000
Montana:	
Lewis and Clark County, Helena	2,700
Nebraska:	
Cass County, Nehawka	2,500
Nemaha County, Auburn	2,500
New Jersey:	
Hunterdon County, Vernoy	2,400 2,550
New York:	
Albany County, South Bethlehem	2,300
Cayuga County, Auburn	2,335 2,340
Dutchess County, Stoneco	2,500
Erie County:	
Buffalo	2,350 2,500
Clarence	2,280
Fulton County, Mayfield	2,500
Herkimer County, Newport	2,400
Jefferson County, Watertown	2,600

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LIMESTONE—continued.

	Pounds.
New York—Continued.	
Madison County, Munnsville	2,300
Perryville	2,300
Montgomery County, Amsterdam	2,400
Oneida County:	
Boonville	2,900
Prospect	2,450
Onondaga County:	
Marcellus	2,500
Syracuse (Elmwood)	2,700
Rockland County, Tompkins Cove	2,500
St. Lawrence County, Ogdensburg	2,850
	2,500
Saratoga County, Saratoga Springs	2,500
Seneca County, Waterloo	2,400
Ulster County:	
Accord	2,700
Marlboro	2,500
Warren County, Glens Falls	2,400
Westchester County, Verplanck	2,500
Ohio:	
Adams County, Peebles	2,400
Allen County:	
Delphos	2,500
Elida	2,500
Harrod	2,400
Lafayette	2,500
Lima	2,500
	2,600
Westminster	2,400
Clinton County:	
Melvin	2,500
New Vienna	2,650
Wilmington	2,650
Crawford County:	
Spore	2,300
Plankton	2,350
Erie County, Sandusky	2,500
Franklin County, West Columbus	2,400
Greene County, Cedarville	2,650
Hamilton County, Newtown	2,600
Hancock County:	
Findlay	2,500
Mount Blanchard	2,500
Vanlue	2,500
Hardin County, Blanchard	2,600
Highland County:	
Greenfield	2,300
Marshall	2,600
Hillsboro	2,600
Jefferson County, Rayland	2,700
Logan County:	
Belle Center	2,600
Middleburg	2,400
Miami County, Piqua	2,500
Ottawa County:	
Elmore	2,700
Oakharbor	2,600
Oakwood	2,500

LIME

Ohio—Conti
Putnam
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Pan
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Seneca C
Van Wer
Wood Co
Wyandot
dusky.
Oklahoma:
Atoka Co
Strin
Choc
Comanch
Johnson
Murray C
Payne C
Pittsburg
Pontotoc
Fitzl
Two
Fit
Tulsa Co
Garn
Sand
Tulsa
Pennsylvania:
Greene C
Lancaste
ville...
Lawrence
City...
Mifflin C
Montgom
South Dakota:
Pennington
City...
Tennessee:
Blount C
Campbell
Davidson
Nash
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Hamilton
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Knox C
Plains..
Marshall C
Maury Co
Carte
Colun
Montgome
ville...
Robertson
field...
Sullivan C
Williamso

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	Pounds.
Texas:	
Limestone County, Tehuacana	2,380
Utah:	
Box Elder County, Lakeside	2,800
Salt Lake County, Salt Lake City	2,600
Virginia:	
Augusta County:	
Craigsville	2,400
Staunton	2,500
Giles County:	
Pembroke	2,400
Sinking Creek	2,400
Loudoun County, Leesburg	2,400
Pulaski County, Belspring	2,700
Rockingham County, Bridgewater	2,500
Tazewell County, Pounding Mill	2,400
Washington County, Bristol	2,600
West Virginia:	
Greenbrier County, Fort Spring	2,500
Mercer County, Bluefield	2,400
Ohio County, Wheeling	2,500 2,600 2,700
Wisconsin:	
Brown County, Greenleaf	2,500
Calumet County:	
Highcliff	2,500
Brillion	2,500
Crawford County, Prairie du Chien	2,500
Dane County, Madison	2,500
Dodge County:	
Neosho	2,500
Knowles	2,500
Door County, Sturgeon Bay	2,500
Fond du Lac County:	
Hamilton	2,500
Marblehead	2,500
Ripon	2,500 2,700
Kewaunee County, Kewaunee	2,500
La Crosse County, Holmen	2,500
Manitowoc County, Quarry	2,500
Milwaukee County, Wauwatosa	2,500 3,200
Monroe County, Sparta	2,500
Outagamie County, Kaukauna	2,600 2,500
Ozaukee County, Belgium	2,500
Racine County, Ives	2,500
Rock County, Beloit	2,400
Sheboygan County:	
Sheboygan	2,600
Sheboygan Falls	2,600
Washington County, Rockfield	2,500
Wisconsin—Continued.	
Waukesha County:	
Lannon	2,500 2,400
Menomonee Falls	2,600
Winnebago County, Neenah	2,500

SANDSTONE.

Arkansas:	
Cleburne County, Snell	2,300
Franklin County, Ozark	2,300
Sebastian County, Fort Smith	2,400
California:	
Alameda County, Oakland	2,600 2,383 2,400
Contra Costa County, Stege	2,700
San Francisco County, San Francisco	2,400
Illinois:	
Alexander County, Tamms (novaculite)	2,160
Minnesota:	
Brown County, New Ulm	2,400
Pine County, Sandstone	2,200
Rock County, Jasper	2,600
New Mexico:	
Sierra County, Elephant Butte	2,610
New York:	
Otsego County, Oneonta	2,400
Schenectady County, Schenectady	2,300
North Carolina:	
Gaston County, Lowell (quartzite)	2,700
Ohio:	
Cuyahoga County, South Euclid	2,100
Marion County, Marseilles	2,500
Oklahoma:	
Le Flore County, Poteau	2,700
Pennsylvania:	
Bucks County, Rushland (argillite)	2,300
Clearfield County, Dubois	2,250
Greene County, Waynesburg	2,400
Jefferson County, Falls Creek	2,700
Lackawanna County, Scranton	2,400
South Dakota:	
Minnehaha County:	
Dell Rapids	2,600
Sioux Falls	2,600
Virginia:	
Campbell County, Lynchburg	2,350
West Virginia:	
Ritchie County, Harrisville	2,500
Wisconsin:	
Juneau County, Necedah	2,600
Monroe County, Oakdale and Norwalk	2,900
Sauk County:	
Ableman	2,600
Baraboo	2,600

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COKE.

By C. E. Lesher.

The author of this report, who is also the au
coal, was engaged, with his clerical assistants, i
during 1917, first with the Committee on C
Council of National Defense and later with t
Administration, and the urgency and volume
the preparation of the report on coke in the
the data were collected in even greater detail t

It is intended that the report on coke in
shortcomings of this summary and shall revi
coke industry in 1916 as well as in 1917. T
in summary form are given in the following
H. L. Bennit, the statistical clerk in charge of

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Coke produced in beehive and by-product ovens in the United States in 1915 and 1916.

1915.

State.	Beehive coke.				By-product coke.				Total.		
	Active ovens.	Coal used (net tons).	Coke produced (net tons).	Value of coke at ovens.	Active ovens.	Coal used (net tons).	Coke produced (net tons).	Value of coke at ovens.	Coal used (net tons).	Coke produced (net tons).	Value of coke at ovens.
Alabama	2,506	1,708,228	1,001,477	$3,086,656	732	2,987,710	2,070,334	$5,458,899	4,695,938	3,071,811	$8,545,555
Colorado	1,334	1,026,019	670,938	2,242,453					1,026,019	670,938	2,242,453
Georgia	62	35,377	20,039	81,170					35,377	20,039	81,170
Illinois					626	2,335,933	1,686,998	7,016,635	2,335,933	1,686,998	7,016,635
Indiana					787	3,685,774	2,768,099	11,604,588	3,685,774	2,768,099	11,604,588
Kentucky	733	462,168	284,516	536,352	108	337,679	241,581	593,417	799,847	526,097	1,129,769
Maryland					120	470,326	313,283	762,664	470,326	313,283	762,664
Massachusetts					400	666,930	504,438	(a)	666,930	504,438	(a)
Minnesota					120	180,767	127,847	475,952	180,767	127,847	475,952
New Mexico	600	732,830	389,411	1,265,268					732,830	389,411	1,265,268
New York					555	975,656	684,461	2,459,463	975,656	684,461	2,459,463
Ohio	200	28,815	19,101	62,416	250	956,656	665,557	2,074,517	985,471	684,658	2,136,933
Pennsylvania	35,984	33,972,018	22,530,567	43,303,821	1,594	4,301,726	3,092,295	9,363,197	38,273,744	25,622,862	52,667,018
Tennessee	805	433,781	283,705	611,281	12	32,084	23,268	62,733	465,865	256,973	674,014
Virginia	1,516	995,396	629,807	1,242,938					995,396	629,807	1,242,938
Washington	249	(a)	(a)	(a)	5	(a)	(a)	(a)	294,879	136,552	700,832
West Virginia	4,270	2,071,001	1,250,235	2,348,468	120	202,762	141,211	412,337	2,273,763	1,391,446	2,760,805
Michigan					205						
Missouri					56						
New Jersey		b 812,883	b 478,459	b 2,164,720	150	b 2,420,379	b 1,753,523	c 8,273,923	3,028,383	2,095,430	c 9,737,811
Utah	726										
Wisconsin					196						
	48,985	42,278,516	27,508,255	56,945,543	6,036	19,554,382	14,072,895	48,558,325	61,832,898	41,581,150	105,503,868

a Included in combined States.

b Includes also Washington.

c Includes also value of Massachusetts coke.

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State.	Beehive coke.				By-product coke.				Total.		
	Active ovens.	Coal used (net tons).	Coke produced (net tons).	Value of coke at ovens.	Active ovens.	Coal used (net tons).	Coke produced (net tons).	Value of coke at ovens.	Coal used (net tons).	Coke produced (net tons).	Value of coke at ovens.
Alabama	4,269	3,158,417	1,828,067	$5,828,057	730	3,635,683	2,470,350	$9,191,082	6,794,100	4,298,417	$15,019,139
Colorado	2,089	1,674,096	1,053,553	3,736,467	.....	.....	.....	.....	1,674,096	1,053,553	3,736,467
Georgia	151	87,178	47,127	232,630	.....	.....	.....	.....	87,178	47,127	232,630
Illinois	.....	.....	.....	.....	626	3,182,650	2,320,400	10,619,066	3,182,650	2,320,400	10,619,066
Indiana	.....	.....	.....	.....	794	4,626,204	3,489,660	16,096,479	4,626,204	3,489,660	16,096,479
Kentucky	827	590,187	362,164	932,533	108	614,922	440,362	1,292,653	1,205,109	802,526	2,225,186
Maryland	.....	.....	.....	.....	118	749,936	489,982	1,387,009	749,936	489,982	1,387,009
Massachusetts	.....	.....	.....	.....	400	728,256	563,048	(a)	728,256	563,048	(a)
Minnesota	.....	.....	.....	.....	146	573,371	431,319	1,968,675	573,371	431,319	1,968,675
New Mexico	966	843,814	502,812	1,718,976	.....	.....	.....	.....	843,814	502,812	1,718,976
New York	.....	.....	.....	.....	555	1,098,249	775,014	3,033,276	1,098,249	775,014	3,033,276
Ohio	197	156,960	104,102	409,784	512	2,447,812	1,699,166	6,484,835	2,604,772	1,803,268	6,894,619
Pennsylvania	44,711	41,299,734	27,159,438	70,508,215	1,854	5,650,352	4,120,257	14,202,090	46,950,086	31,279,695	84,710,305
Tennessee	1,121	605,418	329,702	905,052	11	68,451	52,473	157,013	673,869	382,175	1,062,065
Virginia	3,304	1,977,616	1,242,332	3,024,913	.....	.....	.....	.....	1,977,616	1,242,332	3,024,913
Washington	262	895,604	507,425	2,282,320	5	45,756	27,228	150,295	941,360	534,653	2,432,615
Utah	726										
West Virginia	6,982	3,795,934	2,327,502	5,899,180	120	276,481	193,807	678,325	4,072,415	2,521,309	6,567,505
Michigan	.....	.....	.....	.....	226						
Missouri	.....	.....	.....	.....	56	2,826,379	1,996,295	b10,112,272	2,826,379	1,996,295	b 10,112,272
New Jersey	.....	.....	.....	.....	150						
Wisconsin	.....	.....	.....	.....	196						
	65,605	55,084,958	35,464,224	95,468,127	6,607	26,524,502	19,069,361	75,373,070	81,609,460	54,533,585	170,841,197

a Included in combined States.

b Includes also value of Massachusetts coke.

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Coke produced in the United States, 1913–1916, in net tons.

State.	1913	1914	1915	1916	Increase or decrease, 1916.			
					Quantity.	Percentage.		
						Total.	Beehive.	By-product.
Alabama	3,323,664	3,084,149	3,071,811	4,298,417	+ 1,226,606	+ 39.9	+ 82.5	+ 19.3
Colorado	879,461	666,083	670,938	1,053,553	+ 382,615	+ 57.0	+ 57.0	0
Georgia	42,747	24,517	20,039	47,127	+ 27,088	+135.2	+135.2	0
Illinois	1,859,553	1,425,168	1,686,998	2,320,400	+ 633,402	+ 37.5	0	+ 37.5
Indiana	2,727,025	2,276,652	2,768,099	3,489,660	+ 721,561	+ 26.1	0	+ 26.1
Kentucky	317,084	443,959	526,097	802,526	+ 276,429	+ 52.5	+ 27.3	+ 82.3
Maryland	(a)	87,852	313,283	489,982	+ 176,699	+ 56.4	0	+ 56.4
Massachusetts	(a)	540,631	504,438	563,048	+ 58,610	+ 11.6	0	+ 11.6
Michigan	(a)	(a)	(a)	(a)		+ 11.6	0	+ 11.6
Minnesota	(a)	(a)	127,847	431,319	+ 303,472	+237.4	0	+237.4
Missouri	0	0	(a)	(a)		+ 92.4	0	+ 92.4
New Jersey	255,792	(a)	(a)	(a)		− 21.8	0	− 21.8
New Mexico	467,945	362,572	389,411	502,812	+ 113,401	+ 29.1	+ 29.1	0
New York	758,486	457,370	684,461	775,014	+ 90,553	+ 13.2	0	+ 13.2
Ohio	351,846	521,638	684,658	1,803,268	+ 1,118,610	+163.4	+445.0	+155.3
Pennsylvania	28,753,444	20,258,393	25,622,862	31,279,695	+ 5,656,833	+ 22.1	+ 20.5	+ 33.2
Tennessee	364,578	264,127	256,973	382,175	+ 125,202	+ 48.7	+ 41.1	+125.5
Utah	(a)	(a)	(a)	(b)	(a)			0
Virginia	1,303,603	780,984	629,807	1,242,332	+ 612,525	+ 97.3	+ 97.3	0
Washington	76,221	84,923	136,552	c 534,653	(a)			
West Virginia	2,472,752	1,427,962	1,391,446	2,521,309	+ 1,129,863	+ 81.2	+ 86.2	+ 37.2
Wisconsin	(a)	(a)	(a)	(a)	(a)	+ 21.5	0	+ 21.5
Combined States	2,345,329	1,848,934	2,095,430	1,996,295	+ 298,906			
	46,299,530	34,555,914	41,581,150	54,533,585	+12,952,435	+ 31.1	+ 28.9	+ 35.5

a Included in combined States. b Included with Washington. c Includes Utah.

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Value, at the ovens, of the coke made in the United States, 1913–1916.

State.	1913	1914	1915	1916	Increase or decrease, 1916.			
					Value.	Percentage.		
						Total.	Beehive.	By-product.
Alabama	$9,627,170	$8,408,443	$8,545,555	$15,019,139	+$6,473,584	+ 75.8	+ 88.8	+ 68.4
Colorado	2,815,134	2,203,031	2,242,453	3,736,467	+ 1,494,014	+ 66.6	+ 66.6	0
Georgia	186,304	100,529	81,170	232,630	+ 151,460	+186.6	+186.6	0
Illinois	8,593,581	5,858,700	7,016,635	10,619,066	+ 3,602,431	+ 51.3	0	+ 51.3
Indiana	13,182,136	9,055,937	11,604,588	16,096,479	+ 4,491,891	+ 38.7	0	+ 38.7
Kentucky	753,897	971,060	1,129,769	2,225,186	+ 1,095,417	+ 97.0	+ 73.9	+117.8
Maryland	(a)	299,739	762,664	1,387,009	+ 624,345	+ 81.9	0	+ 81.9
Massachusetts	(a)	(a)	(a)	(a)	(a)	+ 33.2	0	+ 33.2
Michigan	(a)	(a)	(a)	(a)	(a)	+ 15.8	0	+ 15.8
Minnesota	(a)	(a)	475,952	1,968,675	+ 1,492,723	+313.6	0	+313.6
Missouri	0	0	(a)	(a)	(a)	+107.6	0	+107.6
New Jersey	695,041	(a)	(a)	(a)	(a)	− 5.0	0	− 5.0
New Mexico	1,548,536	1,228,045	1,265,268	1,718,976	+ 453,708	+ 35.9	+ 35.9	0
New York	3,301,400	1,726,133	2,459,463	3,033,276	+ 573,813	+ 23.3	0	+ 23.3
Ohio	1,231,554	1,678,686	2,136,933	6,894,619	+ 4,757,686	+222.6	+556.5	+212.6
Pennsylvania	67,929,864	42,447,886	52,667,018	84,710,305	+32,043,287	+ 60.8	+ 62.8	+ 51.7
Tennessee	925,430	642,573	674,014	1,062,065	+ 388,051	+ 57.6	+ 48.1	+150.3
Utah	(a)	(a)	(a)	(b)	(a)			0
Virginia	2,840,275	1,582,419	1,242,938	3,024,913	+ 1,781,975	+143.4	+143.4	0
Washington	432,770	472,531	700,832	c 2,432,615	(a)			
West Virginia	5,504,416	2,847,284	2,760,805	6,567,505	+ 3,806,700	+137.9	+150.8	+ 64.5
Wisconsin	(a)	(a)	(a)	(a)	(a)	+ 18.9	0	+ 18.9
Combined States	9,354,765	8,811,221	9,737,811	10,112,272	+ 2,106,244			
	128,922,273	88,334,217	105,503,868	170,841,197	+65,337,329	+ 61.9	+ 67.6	+ 55.2

a Included in combined States.

b Included with Washington.

c Includes Utah.

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Coke produced in the United States, 1880–1916.

Year.	By-product coke.				Beehive coke.				Total.	
	Quantity (net tons).	Percentage to total.	Value.	Percentage to total.	Quantity (net tons).	Percentage to total.	Value.	Percentage to total.	Quantity (net tons).	Value.
1880..	0	0	0	0	3,338,300	100.0	$6,631,267	100.0	3,338,300	$6,631,267
1885..	0	0	0	0	5,106,096	100.0	7,629,118	100.0	5,106,096	7,629,118
1890..	0	0	0	0	11,508,021	100.0	23,215,302	100.0	11,508,021	23,215,302
1893..	12,850	0.1	.....	.....	9,464,730	99.9	.....	.....	9,477,580	16,523,714
1900..	1,075,727	5.2	$2,635,531	5.6	19,457,621	94.8	44,807,800	94.4	20,533,348	47,443,331
1905..	3,462,348	10.7	10,851,730	15.0	28,768,781	89.3	61,624,466	85.0	32,231,129	72,476,196
1910..	7,138,734	17.1	24,793,016	24.9	34,570,076	82.9	74,949,685	75.1	41,708,810	99,742,701
1911..	7,847,845	22.1	27,297,897	32.4	27,703,644	77.9	56,832,952	67.6	35,551,489	84,130,849
1912..	11,115,184	25.3	42,632,930	38.1	32,868,435	74.7	69,172,183	61.9	43,983,599	111,805,113
1913..	12,714,700	27.5	48,637,852	37.7	33,584,830	72.5	80,284,421	62.3	46,299,530	128,922,273
1914..	11,219,943	32.5	38,080,167	43.1	23,335,971	67.5	50,254,050	56.9	34,555,914	88,334,217
1915..	14,072,895	33.8	48,558,125	46.0	27,508,255	66.2	56,945,643	54.0	41,581,150	105,503,868
1916..	19,069,351	35.0	75,373,070	44.1	35,464,224	65.0	95,468,127	55.9	54,533,585	170,841,197

Statistics of the manufacture of coke in the United States, 1880–1916.

Year.	In operation.		Coal used (net tons).	Percentage yield of coke from coal.	Coke produced (net tons).	Total value of coke at ovens.	Value of coke at ovens, per ton.
	Establishments.	Ovens.					
1880.....	[a] 186	[a] 12,372	5,237,741	63.0	3,338,300	$6,631,267	$1.99
1890.....	[a] 253	[a] 37,158	18,005,209	64.0	11,508,021	23,215,302	2.02
1900.....	345	43,039	32,113,553	63.9	20,533,348	47,443,331	2.31
1910.....	478	96,067	63,088,327	66.1	41,708,810	99,742,701	2.39
1911.....	391	63,480	53,278,248	66.7	35,551,489	84,130,849	2.37
1912.....	439	73,058	65,577,862	67.1	43,983,599	111,805,113	2.54
1913.....	444	72,008	69,239,190	66.9	46,299,530	128,922,273	2.78
1914.....	359	54,638	51,623,750	66.9	34,555,914	88,334,317	2.56
1915.....	354	54,967	61,832,898	67.2	41,581,150	105,503,968	2.54
1916.....	389	72,888	81,609,460	66.8	54,533,585	170,841,197	3.13

[a] Total in existence. No statistics available showing idle establishments.

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Coke ovens in the United States, 1915 and 1916.

1915.

State.	Active.		Idle.		Total.		Abandoned.		Building at end of year.	
	Bee-hive.	By-product.	Bee-hive.	By-product.	Bee-hive.	By-product.	Bee-hive.	By-product.	Bee-hive.	By-product.
Alabama	2,506	732	6,062	18	8,568	750	.....	.....	.....	.....
Colorado	1,334	.....	2,239	.....	3,573	.....	.....	.....	.....	.....
Georgia	62	.....	139	.....	201	.....	.....	.....	.....	.....
Illinois	.....	626	.....	.....	.....	626	.....	.....	.....	.....
Indiana	.....	787	.....	a 25	.....	812	.....	.....	.....	30
Kansas	.....	.....	2	.....	2	.....	.....	.....	.....	.....
Kentucky	733	54	364	.....	1,097	54	.....	.....	.....	54
Maryland	.....	120	.....	.....	.....	120	.....	.....	.....	.....
Massachusetts	.....	400	.....	.....	.....	400	.....	.....	.....	.....
Michigan	.....	205	.....	.....	.....	205	.....	.....	.....	24
Minnesota	.....	120	.....	.....	.....	120	.....	.....	.....	20
Missouri	.....	56	.....	.....	.....	56	.....	.....	.....	.....
Montana	.....	.....	112	.....	112	.....	239	.....	.....	.....
New Jersey	.....	150	.....	.....	.....	150	.....	.....	.....	.....
New Mexico	600	.....	430	.....	1,030	.....	.....	.....	.....	.....
New York	.....	555	.....	.....	.....	555	.....	.....	.....	100
Ohio	200	250	121	93	321	343	.....	.....	.....	657
Oklahoma	.....	.....	50	.....	50	.....	.....	.....	.....	.....
Pennsylvania	35,984	1,594	b17,128	150	53,112	1,744	189	.....	540	212
Tennessee	805	12	1,497	.....	2,302	12	1	.....	.....	.....
Utah	726	.....	.....	.....	726	.....	.....	.....	.....	.....
Virginia	1,516	.....	3,713	.....	5,229	.....	300	.....	17	.....
Washington	249	5	82	.....	331	5	.....	.....	.....	.....
West Virginia	4,270	120	11,958	.....	16,228	120	834	.....	.....	94
Wisconsin	.....	196	228	.....	228	196	.....	.....	.....	.....
	48,985	5,982	44,125	286	93,110	6,268	1,563	.....	557	1,191

1916.

Alabama	4,269	730	4,537	13	8,806	743	62	7	.....	97
Colorado	2,089	.....	1,484	.....	3,573	.....	.....	.....	.....	120
Georgia	151	.....	50	.....	201	.....	.....	.....	.....	.....
Illinois	.....	626	.....	.....	.....	626	.....	.....	.....	.....
Indiana	.....	794	.....	48	.....	842	.....	.....	.....	44
Kansas	.....	.....	2	.....	2	.....	.....	.....	.....	.....
Kentucky	827	108	270	.....	1,097	108	.....	.....	.....	.....
Maryland	.....	118	.....	2	.....	120	.....	.....	.....	240
Massachusetts	.....	400	.....	.....	.....	400	.....	.....	.....	.....
Michigan	.....	226	.....	3	.....	229	.....	.....	.....	40
Minnesota	.....	146	.....	9	.....	155	.....	.....	.....	65
Missouri	.....	56	.....	.....	.....	56	.....	.....	.....	.....
Montana	.....	.....	.....	.....	.....	.....	251	.....	.....	.....
New Jersey	.....	150	.....	.....	.....	150	.....	.....	.....	110
New Mexico	966	.....	94	.....	1,060	.....	.....	.....	94	.....
New York	.....	555	.....	.....	.....	555	.....	.....	.....	160
Ohio	197	512	124	404	321	916	.....	.....	.....	472
Oklahoma	.....	.....	50	.....	50	.....	.....	.....	.....	.....
Pennsylvania	44,711	1,854	7,705	102	52,416	1,956	847	.....	10	700
Tennessee	1,121	11	1,107	1	2,228	12	75	.....	.....	.....
Utah	726	.....	.....	.....	726	.....	.....	.....	.....	.....
Virginia	3,304	.....	1,842	.....	5,146	.....	100	.....	.....	.....
Washington	262	5	69	.....	331	5	.....	.....	.....	.....
West Virginia	6,982	120	8,414	a 94	15,396	214	930	.....	.....	.....
Wisconsin	.....	196	228	.....	228	196	.....	.....	.....	36
	65,605	6,607	25,976	676	91,581	7,283	2,265	7	104	2,084

a New ovens, built but not yet in operation. b Includes 34 new ovens, built but not yet in operation.

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Beehive coke ovens at end of each year, 1912–1916.

State.	1912	1913	1914	1915	1916
Alabama	9,588	9,584	8,535	8,568	8,806
Colorado	3,588	3,588	3,573	3,573	3,573
Georgia	251	251	201	201	201
Illinois	26	.....	.....	.....	.....
Indiana	10	.....	.....	.....	.....
Kansas	3	2	2	2	2
Kentucky	1,049	995	1,097	1,097	1,097
Montana	451	351	351	112	.....
New Mexico	1,030	1,030	1,030	1,030	1,030
Ohio	322	322	321	321	321
Oklahoma	260	260	260	50	50
Pennsylvania	52,314	53,466	52,553	53,112	52,416
Tennessee	2,584	2,427	2,303	2,302	2,228
Utah	650	726	726	726	726
Virginia	5,408	5,695	5,435	5,229	5,146
Washington	313	331	331	331	331
West Virginia	18,944	17,706	17,000	16,228	15,396
Wisconsin	228	228	228	228	228
	97,019	96,962	93,946	93,110	91,581

By-product ovens at end of each year, 1912–1916.

State.	1912		1913		1914		1915		1916	
	Built.	Building.	Built.	Building.	Built.	Building.	Built.	Building.	Built.	Building.
Alabama	620	100	700	20	750	.....	750	.....	743	97
Colorado	.....	.....	.....	.....	.....	.....	.....	.....	.....	120
Illinois	568	40	568	58	586	40	626	.....	626	.....
Indiana	632	169	749	41	789	33	812	30	842	44
Kentucky	.....	41	54	.....	54	.....	54	54	108	.....
Maryland	200	6	[a] 0	120	120	.....	120	.....	120	240
Massachusetts	400	.....	400	.....	400	.....	400	.....	400	.....
Michigan	165	40	205	.....	205	.....	205	24	229	40
Minnesota	50	92	50	90	140	90	120	20	155	65
Missouri	.....	.....	.....	56	.....	56	56	.....	56	.....
New Jersey	150	.....	150	.....	150	.....	150	.....	150	110
New York	555	.....	555	.....	555	100	555	100	555	160
Ohio	149	119	149	119	217	51	343	657	916	472
Pennsylvania	1,442	150	1,592	.....	1,522	262	1,744	212	1,956	700
Tennessee	.....	.....	.....	.....	.....	12	12	.....	12	.....
Washington	.....	.....	.....	.....	5	.....	5	.....	5	.....
West Virginia	120	.....	120	.....	120	.....	120	94	214	.....
Wisconsin	160	36	196	.....	196	.....	196	.....	196	36
	5,211	793	[a] 5,488	504	5,809	644	6,268	1,191	7,283	2,084

[a] At the close of 1913 the 200 ovens at Sparrows Point works of the Maryland Steel Co. that were operated during the year were being torn down to be replaced by 120 ovens of larger dimensions.

By-product ovens in the United States at the end of 1916.

State.	Koppers.	United Otto.[a]	Semet-Solvay.	Rothberg.	Didier.	Gas machinery.	Roberts fueless.	Klönne.	Wilputte.	Total.
Alabama	443	.....	300	.....	.....	.....	.....	.....	.....	743
Illinois	315	.....	293	.....	.....	.....	.....	.....	18	626
Indiana	646	100	41	.....	.....	33	.....	22	.....	842
Kentucky	.....	.....	108	.....	.....	.....	.....	.....	.....	108
Maryland	120	.....	.....	.....	.....	.....	.....	.....	.....	120
Massachusetts	.....	400	.....	.....	.....	.....	.....	.....	.....	400
Michigan	.....	54	175	.....	.....	.....	.....	.....	.....	229
Minnesota	90	65	.....	.....	.....	.....	.....	.....	.....	155
Missouri	56	.....	.....	.....	.....	.....	.....	.....	.....	56
New Jersey	.....	150	.....	.....	.....	.....	.....	.....	.....	150
New York	.....	188	86	281	.....	.....	.....	.....	.....	555
Ohio	692	100	100	.....	.....	.....	24	.....	.....	916
Pennsylvania	516	903	360	.....	150	27	.....	.....	.....	1,956
Tennessee	.....	.....	.....	.....	.....	.....	12	.....	.....	12
Washington	.....	.....	.....	.....	.....	.....	.....	5	.....	5
West Virginia	94	.....	120	.....	.....	.....	.....	.....	.....	214
Wisconsin	.....	36	160	.....	.....	.....	.....	.....	.....	196
	2,972	1,996	1,743	281	150	60	36	27	18	7,283

[a] Includes the Otto-Hoffman and Schniewind types.

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By-product ovens under construction in the United States at the end of 1916.

State.	Koppers.	United-Otto.	Semet-Solvay.	Wilputte.	Total.
Alabama	37			60	97
Colorado	120				120
Indiana	44				44
Maryland	240				240
Michigan				40	40
Minnesota	65				65
New Jersey	110				110
New York		100	60		160
Ohio	472				472
Pennsylvania	700				700
Wisconsin		36			36
	1,788	136	100	60	2,084

Coal used in the manufacture of coke in the United States in 1915 and 1916.

1915.

State.	Coal used (net tons).	Total value of coal.	Value of coal per ton.	Quantity of coal per ton of coke (net tons).	Value of coal to a ton of coke.
Alabama	4,695,938	$6,955,215	$1.48	1.529	$2.263
Colorado	1,026,019	1,850,551	1.80	1.678	3.020
Georgia	35,377	64,869	1.83	1.765	3.230
Illinois	2,335,933	6,697,209	2.87	1.385	3.975
Indiana	3,685,774	10,830,362	2.94	1.332	3.916
Kentucky	799,847	1,000,721	1.25	1.520	1.900
Maryland	470,326	1,185,926	2.52	1.501	3.783
Massachusetts	666,930	(a)	(a)	1.322	(a)
Minnesota	180,767	490,864	2.72	1.414	3.846
New Mexico	732,830	804,550	1.10	1.882	2.070
New York	975,656	2,435,257	2.50	1.071	2.678
Ohio	985,471	1,853,574	1.88	1.439	2.705
Pennsylvania	38,273,744	43,779,862	1.14	1.494	1.703
Tennessee	465,865	498,256	1.07	1.813	1.940
Virginia	995,396	762,233	.77	1.580	1.217
Washington	204,879	604,867	2.95	1.500	4.425
West Virginia	2,273,763	1,864,315	.82	1.633	1.339
Other States b	3,028,383	c 8,355,493	c 2.26	1.445	c 3.211
	61,832,898	90,034,124	1.46	1.487	2.171

1916.

Alabama	6,794,100	$11,000,238	$1.62	1.581	$2.561
Colorado	1,674,096	2,920,511	1.74	1.589	2.765
Georgia	87,178	157,840	1.81	1.850	3.349
Illinois	3,182,650	9,319,729	2.93	1.372	4.020
Indiana	4,626,204	14,086,992	3.05	1.326	4.044
Kentucky	1,205,109	1,536,175	1.27	1.502	1.908
Maryland	749,936	2,287,724	3.05	1.531	4.670
Minnesota	573,371	1,686,454	2.94	1.329	3.907
New Mexico	843,814	918,699	1.09	1.678	1.829
New York	1,098,249	3,002,135	2.73	1.417	3.863
Ohio	2,604,772	6,629,956	2.55	1.444	3.682
Pennsylvania	46,950,086	66,799,644	1.42	1.501	2.131
Tennessee	673,869	770,392	1.14	1.763	2.010
Utah and Washington	941,360	1,689,805	1.80	1.761	3.170
Virginia	1,977,616	1,718,394	.87	1.592	1.385
West Virginia	4,072,415	3,891,961	.96	1.615	1.550
Other States b	3,554,635	9,651,045	2.72	1.389	3.778
	81,609,460	138,067,694	1.69	1.496	2.528

a Included in other States.
b 1915: Michigan, Missouri, New Jersey, Utah, and Wisconsin—1916: Utah omitted.
c Includes also Massachusetts.

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Percentage yield of coke from coal, 1912–1916.

State.	1912	1913	1914	1915	1916
Alabama	64.9	63.6	65.9	65.4	63.3
Colorado	66.0	65.1	63.5	65.4	62.9
Georgia	50.0	51.5	54.1	56.6	54.1
Illinois	76.2	74.9	73.8	72.2	72.9
Indiana	81.8	77.1	72.8	75.1	75.4
Kansas	70.0	0	0	0	0
Kentucky	62.4	61.9	66.0	65.8	66.6
Maryland	65.8	69.4	67.6	66.7	65.3
Massachusetts	75.5	76.3	76.4	75.6	77.3
Michigan	75.4	76.2	74.1	72.0	71.9
Minnesota	69.6	66.9	68.4	70.7	75.2
Missouri	0	0	0	77.0	76.9
New Jersey	78.4	75.4	77.6	77.0	61.4
New Mexico	60.9	59.4	54.9	53.1	59.6
New York	72.6	71.1	69.0	70.2	70.6
Ohio	69.2	69.3	70.0	69.5	69.2
Pennsylvania	66.5	66.6	66.9	66.9	66.6
Tennessee	54.0	52.5	54.2	55.2	56.7
Utah	56.8	56.9	.....	.....	.....
Virginia	62.2	64.7	59.2	63.3	62.8
Washington	62.6	64.2	63.7	66.7	61.5
West Virginia	60.7	61.3	61.6	61.2	61.9
Wisconsin	69.6	76.2	70.8	70.3	70.5
Total average	67.1	66.9	66.9	67.2	66.8

By-products obtained from coke-oven operations in 1916.

Product.	Quantity.	Value.	Average value.
Tar obtained and sold ..... gallons	185,506,024	$4,865,921	$0.026
Ammonia obtained and sold:			
Sulphate ..... pounds	271,832,816	8,496,278	.031
Liquor ..... gallons	3,224,718	602,241	.318
Anhydrous or free ammonia [a] ..... pounds	47,739,602	5,053,724	.106
Gas produced ..... M. cubic feet	291,991,844	.....	.....
Surplus gas sold or used:			
Illuminating ..... do	20,551,916	3,639,821	.177
Domestic fuel ..... do	6,558,484	2,849,909	.435
Industrial fuel ..... do	82,951,207	4,289,478	.052
Benzol products:			
Crude light oils ..... gallons	16,572,544	4,962,055	.299
Secondary light oils ..... do	767,373	257,800	.336
Benzol ..... do	21,079,500	13,159,374	.624
Toluol ..... do	3,939,636	11,238,268	2.853
Solvent naphtha ..... do	1,350,726	383,584	.284
Naphthalene ..... pounds	8,820,405	289,688	.033
Other products [b]	.....	143,398	.....
Coke breeze ..... net tons	1,030,830	1,700,056	1.65
		61,931,595	
Coke ..... do	19,069,361	75,373,070	3.95
		137,304,665	

[a] Includes liquor and sulphate sold on pound basis of NH_3.
[b] Includes drip oil, spent oxide, sodium ferrocyanide, domestic coke and coke dust, retort carbon, and xylol.

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By-products obtained in the manufacture of coke in 1916.

Products obtained and sold.	Quantity.	Value.
Surplus gas.....M. cubic feet..	110,061,607	$10,779,208
Tar.....gallons..	185,506,024	4,865,921
Ammonia, sulphate or reduced to equivalent in sulphate.....pounds..	271,832,816	8,496,278
Ammonia liquor.....gallons..	3,224,718	602,241
Anhydrous ammonia *a*.....pounds..	47,739,602	5,053,724
Other by-products *b*.....	.....	32,134,223
		61,931,595
Coke.....net tons..	19,069,361	75,373,070
		137,304,665

a Mainly ammonical liquor and sulphate sold on pound basis of NH_3.
b Mainly benzol products.

By-product coke produced in the United States, 1907–1916, in net tons.

State.	1907	1908	1909	1910	1911
Alabama	464,761	475,552	533,903	557,148	669,433
Illinois	368,730	360,776	1,276,404	1,513,126	1,610,212
Indiana	.....	.....	.....	84,046	916,411
Kentucky	.....	.....	.....	.....	.....
Maryland	332,253	270,916	315,587	335,373	343,451
Massachusetts	466,458	453,883	444,349	450,001	477,564
Michigan	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)
Minnesota	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)
Missouri	.....	.....	.....	.....	.....
New Jersey	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)
New York	588,478	473,569	523,551	652,459	686,172
Ohio	146,011	72,356	83,114	163,487	202,298
Pennsylvania	2,045,599	1,133,039	1,849,391	2,052,973	1,493,509
Tennessee	.....	.....	.....	.....	.....
Washington	.....	.....	.....	.....	.....
West Virginia	153,003	.....	86,393	77,977	165,099
Wisconsin	402,043	400,936	463,904	528,660	577,619
Combined States	640,563	560,199	678,048	723,484	706,077
	5,607,899	4,201,226	6,254,644	7,138,734	7,847,845

State.	1912	1913	1914	1915	1916
Alabama	1,349,797	2,022,959	2,031,535	2,070,334	2,470,350
Illinois	1,764,944	1,859,553	1,425,168	1,686,998	2,320,400
Indiana	2,616,339	2,727,025	2,276,652	2,768,099	3,489,660
Kentucky	.....	69,023	196,777	241,581	440,362
Maryland	304,715	236,423	87,852	313,283	489,982
Massachusetts	511,596	531,384	540,631	504,438	563,048
Michigan	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)
Minnesota	(*a*)	(*a*)	(*a*)	127,847	431,319
Missouri	.....	.....	.....	(*a*)	(*a*)
New Jersey	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)
New York	794,618	758,486	457,370	684,461	775,014
Ohio	241,725	236,032	453,800	665,557	1,699,166
Pennsylvania	1,974,619	2,628,680	2,184,336	3,092,295	4,120,257
Tennessee	.....	.....	.....	23,268	52,473
Washington	.....	.....	(*a*)	(*a*)	27,228
West Virginia	188,373	136,152	46,287	141,211	193,807
Wisconsin	578,875	645,822	(*a*)	(*a*)	(*a*)
Combined States	789,563	863,161	1,519,535	1,753,523	1,996,295
	11,115,164	12,714,700	11,219,943	14,072,895	19,069,361

a Included in combined State.

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Coal used in the manufacture of by-product coke in the United States, 1907–1916, in net tons.

State.	1907	1908	1909	1910	1911
Alabama	671,334	685,354	770,319	789,212	928,255
Illinois	506,388	500,400	1,681,493	1,971,386	2,087,870
Indiana				107,402	1,137,257
Kentucky					
Maryland	456,208	375,515	464,788	511,622	518,738
Massachusetts	624,816	594,095	572,142	581,955	616,614
Michigan	(a)	(a)	(a)	(a)	(a)
Minnesota	(a)	(a)	(a)	(a)	(a)
Missouri					
New Jersey	(a)	(a)	(a)	(a)	(a)
New York	819,423	664,121	727,569	910,293	955,067
Ohio	195,877	102,832	123,471	227,327	285,836
Pennsylvania	2,681,179	1,483,762	2,422,239	2,696,645	1,969,950
Tennessee					
Washington					
West Virginia	205,371		125,656	114,779	221,609
Wisconsin	509,042	519,617	593,931	672,707	770,539
Combined States	836,536	773,362	908,521	965,714	954,549
	7,506,174	5,699,058	8,390,129	9,529,042	10,446,584

State.	1912	1913	1914	1915	1916.
Alabama	1,873,581	2,832,282	2,909,348	2,987,710	3,635,683
Illinois	2,317,307	2,481,198	1,932,132	2,335,933	3,182,650
Indiana	3,198,874	3,535,136	3,125,207	3,635,774	4,626,204
Kentucky		98,846	280,456	337,679	614,922
Maryland	462,998	372,005	129,891	470,326	749,936
Massachusetts	677,793	696,679	707,718	666,930	728,256
Michigan	(a)	(a)	(a)	(a)	(a)
Minnesota	(a)	(a)	(a)	180,767	573,371
Missouri				(a)	(a)
New Jersey	(a)	(a)	(a)	(a)	(a)
New York	1,095,198	1,067,207	659,418	975,656	1,098,249
Ohio	337,987	327,694	643,169	956,656	2,447,812
Pennsylvania	2,676,751	3,492,227	2,964,559	4,301,726	5,650,352
Tennessee				32,084	68,451
Washington			(a)	(a)	45,756
West Virginia	252,849	192,270	64,314	202,762	276,481
Wisconsin	831,984	847,469	(a)	(a)	(a)
Combined States	1,042,221	1,152,356	2,063,809	2,420,379	2,826,379
	14,767,543	17,095,369	15,500,021	19,554,382	26,524,502

a Included with combined States.

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